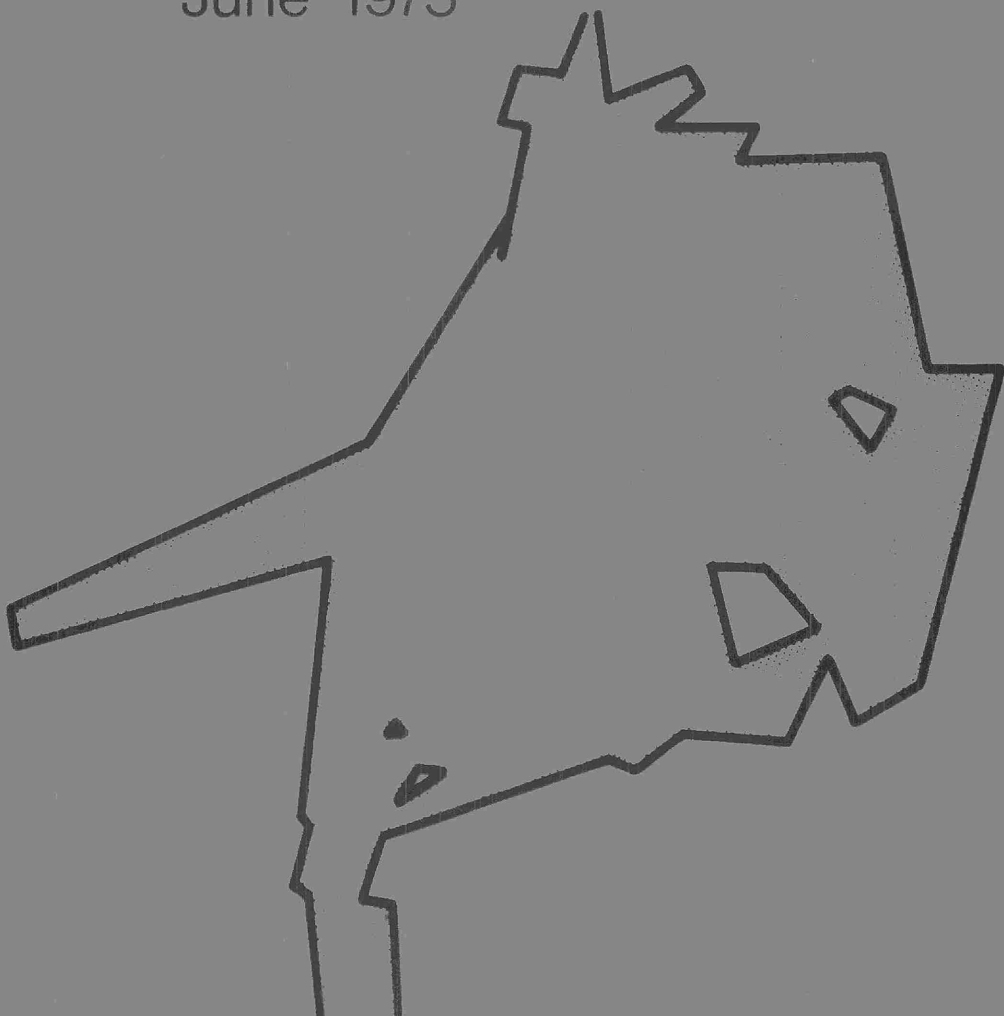
LAKE SIMCOE BASIN

A WATER QUALITY AND USE STUDY

June 1975



Ministry of the Environment
Ontario

Hon. William G. Newman, *Minister*
Everett Biggs, *Deputy Minister*

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INTRODUCTION

Lake Simcoe due to its proximity to the Province's largest population centres, its generally excellent water quality and its suitability for a wide variety of water-oriented activities is one of Southern Ontario's prime cottaging and recreational areas. For many of the same reasons, it is also one of the more desirable areas for urban and industrial development.

The increasing pressure for urbanization and the desire to protect the recreational value of one of southern Ontario's largest lakes led the Ontario Ministry of the Environment to conduct a five-year study into the status of water quality and water use of Lake Simcoe. Preliminary studies in Kempenfelt Bay were conducted during the summer of 1970 and the intensive basin-wide program was initiated in the spring of 1971 and continued in 1972. The investigation was designed to meet the following objectives:

1. To determine the present state of water quality throughout the lake basin.

2. To identify sources of pollution, measure the magnitude of each source and determine its effects on water quality;

3. To catalogue water uses throughout the basin; and

4. To develop a water quality management guide for the protection of Lake Simcoe waters.

It should be pointed out that the particular emphasis of this study was directed to the preservation and, wherever necessary, restoration of the water quality of the lake. It is recognized that many localized water quality problems do exist; in fact, several were identified in the course of the investigations and are discussed in this report. These localized problems, as they are identified have been, or will be, dealt with individually by staff of the Central Region of the MOE or other appropriate authorities.

As part of this report, an evaluation of the Lake Simcoe fisheries prepared by the Lake Simcoe Fisheries Assessment Unit of the Ministry of Natural Resources has been included.

ACKNOWLEDGEMENTS

The Ministry of the Environment wishes to thank all cottagers who answered our mail questionnaires and the lake residents who were kind enough to spend some time talking with us about Lake Simcoe during our personal interview tours. We are also indebted to the marina operators and others around the lake who offered facilities and assistance to our field survey crews.

Special thanks are extended to the Ministry of Natural Resources Staff of the Lake Simcoe Fisheries Assessment Unit - R.L. Des Jardine, J.N. Lawrence and, early in the study, T.J. Millard for "The Fisheries of Lake Simcoe" section of this report.

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CHAPTER 1 - SUMMARY AND RECOMMENDATIONS

1.1 SUMMARY

Lake Simcoe is the largest body of water in Southern Ontario, excluding the Great Lakes. Because of its many natural amenities and its prime geographical location there has been a traditional and steadilyincreasing demand on the lake's capacity for swimming, fishing, boating, cottaging, picnicking, camping and the many other summer and winter recreational pursuits.

It is anticipated that many of the municipalities in the lake's watershed will experience substantial growth over the next few decades. The associated environmental pressures on the lake and its tributaries, if development is left uncontrolled, could result in a significant degradation of the aquatic resources. Preservation of Lake Simcoe's environmental quality requires careful planning and management on a basinwide basis.

In order to assess present water quality conditions in the basin and to determine those factors of significance in the management of Lake Simcoe's water resources, the Ministry of the Environment carried out a variety of field surveys over the period 1970 to 1974. These studies included public attitude surveys chemical-physical quality and aquatic biology field investigations. The Ministry of Natural Resources also conducted fish population and habitat studies as part of their regular program in Lake Simcoe.

From personal interviews and a cottager's questionaire, most respondents indicated that Lake Simcoe could be rated as good to excellent for recreational uses, but some aspects of the quality of the lake's aquatic environment has appeared to decline over the past few years. Chief concerns appear to centre around increasing algal growths and changing fishing success. Many expressed the feeling that appropriate measures should be taken to control cottage development and septic tank drainage and, generally, to enforce stricter measures to control pollution.

The various water quality surveillance programs and intensive studies conducted in Lake Simcoe from 1970 to 1974, indicate that in general, water quality in Lake Simcoe is satisfactory. Levels of phosphorus and nitrogen were found to be fairly low (total phosphorus mean - 0.017 mg/l; total nitrogen mean - 0.38 mg/l) with little horizontal or vertical variation throughout the open lake. The notable areas of higher nutrient levels were lower Cook Bay in the vicinity of the mouth of the Holland River; Shingle Bay near Ben's Ditch (City of Orillia STP outfall); and, to a lesser extent, the extreme west end of Kempenfelt Bay near the City of Barrie. Slightly higher nutrient levels were also found adjacent to the mouths of the major tributaries draining to the lake, but generally within a one or two hundred meter radius around the mouths, normal open-lake levels once again prevailled.

A well defined pattern in the development of the vertical thermal profile was observed each year. Following the ice break-up, usually in April, the water temperature was 4 to 5°C throughout the horizontal and vertical planes. Surface waters then began to heat starting from the shores and shallow areas and by late July or early August peaked at 20 to 22°C. Bottom waters began to heat in late May and June and the temperature in this lower zone continued to rise until 10 to 11° C was reached usually by late August. By July a thermocline had started to develop and continued to intensify through August at a depth of 15 to 18 meters. Autumn turn-over and a return to fairly uniform temperatures throughout the lake usually occurred in late September or October.

Dissolved oxygen levels in the surface waters were satisfactory at or near 100 per cent saturation throughout the year. Discharges of organic material appeared to have no measurable impact because there was no significant oxygen depletion measured at any location within the epilimnetic (surface) zone. The deep water area (hypolimnion) did illustrate dissolved oxygen depletion during the period of thermal stratification from mid-summer through early fall. Following spring turn-over dissolved oxygen in the deeper waters were near 100 per cent saturation. As the summer progressed and the thermocline was established dissolved oxygen levels began to decline and by mid-September reached a low of 20 to 30 per cent saturation. Following autumn turn-over saturated dissolved oxygen levels were once again established and maintained through the winter months.

In addition to monitoring dissolved oxygen levels throughout the surface and deeper areas of the lake, samples were taken from within the rocky spawning shoals. Oxygen levels were near 100 per cent saturation indicating an excellent potential for egg development.

Lake clarity was measured using a secchi disc. The average secchi disc reading for the open lake was about four meters, indicative of reasonably clear waters. More turbid waters were encountered in lower Cook Bay and along the shallow east shore. In general, water clarity in most areas decreased as the summer progressed, likely the direct result of increased phytoplankton populations.

To measure free-floating algal populations chlorophyll a and phytoplankton analyses were employed. For the most part the distribution of phytoplankton throughout the lake was fairly uniform in density (low to moderate) and generic composition of the four main groups of algae present, blue-greens and flagellates dominated throughout most of the year. High levels of diatoms, however, were found in May and June, Green algae were found only in low densities throughout the sampling period.

Since the autumn of 1971, algae scums have been observed and recorded annually on Lake Simcoe. These scums, which from a distance appear somewhat like algae blooms, are caused by blue-green algae buoying-up to form a thin surface scum. The

scums are usually very short-lived breaking up with wind and wave action.

Due to the extensive areas of exposed shoreline and shifting sand or rocky bottom in many parts of the lake, Lake Simcoe was found to support a very small crop of aquatic weeds. Substantial macrophytic growths were limited to the sheltered, shallow areas such as Shingle, McPhee and Barnstable bays. The greatest abundance of aquatic weeds occurred in the southern end of Cook Bay. Some cottagers in this area have in the past been troubled with shoreline accumulations of decomposing weeds during the late summer and fall.

Significant amounts of attached algae were found at about one-third of the sampling stations located around Lake Simcoe's shoreline. Cladophora was by far the most common and abundant algal type. This bright green filamentous aquatic plant which grows on rocks, dock cribs, etc. is slimy to the touch and can detract from the aesthetic and recreational value of a shoreline. Several cottagers have indicated that attached algae has only started to appear over the past few years. There was little evidence of attached algal growths on the rocky spawning shoals.

In studies of the bottom faunal community, Lake Simcoe was found to support a wide variety of benthic invertibrates. Densities were found to be fairly high throughout the lake averaging about 2000 organisms per square meter. Shallow water zones, 0 to 17 meters, in the open lake contained a particularly diverse community dominated by midges, worms, amphipods, fingernail clams, snails, mayflies and caddisflies. In Cook Bay, with its predominantly mud bottom, the benthic community was reasonably diversified but differed from the open lake as indicated by the scarcity of mayflies, caddisflies and fingernail clams.

In the deeper parts of the lake, greater that 17 meters, tubificid worms dominated the benthic community. This is likely because of the organic mud bottom and low dissolved oxygen levels experienced during the late summer and early autumn. This benthic community of the hypolimnetic zone of Lake Simcoe is indicative of eutrophic conditions. It is interesting to note that in the early 1930's, D. S. Rawson collected samples and classified the hypolimnetic benthos as eutrophic. However, at that time there was still some evidence of oligotrophic species not found in the 1970's studies. A comparison of the findings is interesting because it shows that the transition of the benthic community from oligotrophic to eutrophic indicators is not a recent occurence, but has probably taken many decades, and possibly has been accelerated by man's recent activities within the basin.

Lake Simcoe supports about fifteen percent of Ontario's angling population second only to Georgian Bay. Together with Lake Couchiching, it provides just less than one million angler-days per year. The lake offers an extensive sport fishery during all four seasons of the year. The wide variety

of natural habitat offer the fisherman the oportunity to seek lake trout, whitefish, small-mouth bass, yellow pickerel, northern pike, yellow perch, smelt or fresh-water herring (ciscoe). In recent years a substantial decline in the whitefish catches along with increasing numbers of the less desirable smelt and yellow perch has aroused concern. The causes of such a change are complex. A decline in the natural whitefish habitat, predation and inter-specific competition for food could all be factors. The Ministry of Natural Resources through its Lake Simcoe Fisheries Assessment Unit located at Sibbald Point Park is planning a number of studies to gain a better understanding of the Lake Simcoe fishery.

To complement the water quality studies carried out in the lake proper and to determine water quality conditions within the rest of the basin, studies were undertaken in the major tributary streams. As part of these investigations, routine monthly sampling was carried out at the mouths of all significant streams entering the lake. In addition, samples were collected at monthly intervals downstream from municipal sewage treatment plants and other key locations. Intensive surveys were carried out on the larger tributary streams to measure the water quality status and to determine the magnitude and significance of inland sources of pollution on downstream reaches of the tributary streams and on the lake itself.

Water quality problems are quite apparent in the Holland River Basin particularly the East Branch where wastewater discharges from the municipalities of Aurora and Newmarket result in elevated biochemical oxygen demand, phosphorus, nitrogen and bacteria levels. Large diurnal dissolved oxygen fluctuations resulting from profuse aquatic plant and algal growths were measured in several areas of the basin but were particularly severe downstream from Newmarket. Water quality conditions are somewhat better in the West Branch. Local impairment, however, was noted through Schomberg. With the exception of the spring run-off period, the muck farming area of the Holland Marsh does not drain to the Holland River. In fact, during the growing season irrigation water is drawn from the canal system surrounding the farming area. In the spring, water is pumped from the marsh to the Holland River contributing nutrients and silt to the lower river. Because the pumping is undertaken in high river flow periods, the impact of the discharge is not felt directly downstream but undoubtedly the nutrients and solids from both the East and West branches do contribute to the build-up of sediments and aquatic weed growth in the lower reaches of the river and the southerly section of Cook Bay.

In general, water quality conditions in the other tributaries were satisfactory. Some of the notable exceptions were: bacteriological impairment in the Maskinonge River through Jersey and in some of the upstream agricultural areas; increased levels of organics, nutrients and bacteria downstream from the Uxbridge STP in Uxbridge Brook (Pefferlaw River); and, elevated bacterial levels in the Beaverton River

in the vicinities of Beaverton and Cannington, likely the result of uncontrolled urban run-off.

Following the completion of field investigations, the findings of the various lake and tributary stream studies were evaluated to identify the probable causes of water quality degradation and use impairment and subsequently, to develop appropriate remedial measures.

The more significant pollution problems in the river basins are the direct result of controlled and uncontrolled waste-water discharges from the inland municipalities. Improved sewage treatment or export of sewage effluent from the basin (as in the case of Aurora and Newmarket joining the YorkDurham Provincial Sewage Works System), the elimination of sewage by-passes and, possibly, urban storm water treatment should result in substantial improvements in water quality. The minimization of material inputs from diffuse rural sources through improved agricultural practices, erosion control, etc. should also contribute to the general upgrading of water quality conditions in the streams draining to Lake Simcoe and, ultimately, Lake Simcoe itself.

Because most of the lake-wide problems are related directly or indirectly to attached or free-floating algal growth, it was determined that protection of the aquatic environment could be achieved principally by limiting nutrient input. Nitrogen and phosphorus are two algal nutrients which most frequently limit aquatic plant growth. Nitrogen is readily abundant in all material discharges to the lake, it is very difficult and costly to remove at treatment works, and it can be taken directly from the atmosphere by some algae. Phosphorus is also readily abundant in most waste discharges, but unlike nitrogen it can be effectively and economically removed from municipal wastes. Studies in Ontario lakes have shown phosphorus to be a more limiting nutrient than nitrogen. For these reasons, phosphorus was selected as the key nutrient to control.

Prior to 1974, municipal sewage treatment plants discharging directly to the lake and to the tributary streams accounted for over 40% of the total phosphorus input to the Lake Simcoe Basin. Following the installation of phosphorus removal facilities at all major plants in the basin, it was calculated that the STP's contribution of phosphorus was reduced to slightly over 20% of the total input, with tributary drainage (excluding STP loadings) accounting for a little more that 40%, precipitation 15%, private waste disposal services (i.e., septic tanks) 10% and all other sources about 10%.

Significant individual inputs may have a localized impact on water quality and use but dispense rapidly without apparently impairing general lake water chemistry. However, the cumulative effects of these inputs increases the build-up of phosphorus and other deleterious materials in the lake.

Over the past few years limnologists have developed techniques which relate the trophic status of a lake to nutrient

loadings. Prior to phosphorus removal at the sewage treatment plants in 1974, the phosphorus loading level to Lake Simcoe (0.194 $g/m^2/yr$) placed the lake in the mesotrophic state approaching eutrophic conditions. Following the initiation of phosphorus removal, it was calculated that the remaining phosphorus loading of 0.14 $g/m^2/yr$ would place Lake Simcoe still in the mesotrophic range but much closer to the oligotrophic state. It is not known at this time if free-floating and attached algae growths will be reduced and associated problems minimized as a direct result of phosphorus reduction at the STP's. Only observation and testing over the next few years will determine this. Future investigations may show that further reductions of phosphorus and perhaps other materials will be necessary. It is known, however, that the phosphorus loading measured prior to 1974 is too high and in light of present and future development plans for the Lake Simcoe Basin, every effort must be made to minimize phosphorus inputs so that pre-1974 loadings will not be approached or exceeded in the future.

In addition to municipalities providing the highest practicable level of treatment, the responsibility of limiting the input of polluting materials also lies with individuals using the basin - cottagers, boaters, campers, developers, farmers. With a positive effort by everyone, Lake Simcoe's water quality and wide variety of uses can be preserved.

1.2 RECOMMENDATIONS

In the recommendations which follow, very stringent wastewater control requirements are proposed for all sewage treatment plant discharges and other sources of waste material from municipalities. In addition, several recommendations to minimize pollution from land drainage and private sources (cottages, boats, etc.) are presented. Only with the implementation of such recommendations can the high quality recreational resource and the capability of the basin to absorb major urban development co-exist.

1.2.1 General Development Considerations

Land use development (municipal expansion; cottage, campsite, day-park development, etc.) in the Lake Simcoe Basin should evolve in an orderly manner. Proposals including wastewater discharges to the lake or tributary streams should be reviewed to incorporate both local and lake-wide implications on water quality and use. Major development plans should be coordinated on a basin wide basis and implementation staged so that the impact of development on water quality can be assessed and future development managed in light of reserve capacities within the basin.

1.2.2 Direct Municipal Wastewater Discharges to Lake Simcoe

(a) All existing municipal sewage treatment plants should be maintained at their highest level of treatment efficiency.

(b) All new sewage treatment plants and expansions or replacements for existing plants should incorporate the most up-to-date equipment and methods to ensure the highest level of waste treatment practicably possible. Particular emphasis should be placed on reducing the total phosphorus concentration in the final effluent to 0.3 mg/l or less and eliminating organic solids.

(c) All unauthorized municipal or industrial wastewater discharges gaining access to the lake should be directed to sanitary sewerage systems.

(d) All new communities or extensions to existing municipalities must provide the means to collect and treat urban storm drainage if it is determined that this type of wastewater discharge will impair quality and use in the lake or bays.

In existing municipalities where storm water treatment is not practicably possible, good housekeeping practices should be employed to minimize the impact of storm water drainage on the quality of the lake (e.g. routine programs of street sweeping, cleaning of catchment sumps, conservative use of deicing salts, etc.).

(e) Waste stabilization lagoons with long-term retention should be discharged in the late autumn (November) and, if necessary, during the early spring prior to the aquatic plant growing season. All lagoons should be treated for phosphorus removal prior to discharge.

(f) Wastewater discharges containing bacterial contaminants which could potentially affect the use of Lake Simcoe must receive adequate disinfection.

1.2.3 Wastewater Discharges to Lake Simcoe Tributary Streams

(a) All existing sewage treatment plants now providing phosphorus removal should ensure that the level of 1 mg/l or less of total phosphorus in the final effluent is being consistently met.

(b) Wastewater treatment requirements with respect to BOD_5, nutrients, solids, bacteria and other pollutants must meet the specific guidelines established by the Ontario Ministry of the Environment for the protection of the receiving watercourse downstream from municipal sewage treatment plants or industrial waste sources.

(c) If it is demonstrated that a wastewater discharge (municipal, industrial, storm drainage, etc.), while meeting criteria for the protection of the tributary stream, is in fact resulting in water quality or use impairment in Lake Simcoe proper, the necessary steps must be taken to upgrade treatment to the level required for the protection of Lake Simcoe.

(d) Municipal sewage treatment plant discharges from the towns of Aurora and Newmarket should be directed to the York-Durham Provincial sewage works system as soon as it is practicably possible. Until that time these municipalities should provide the high degree of wastewater treatment required in Ontario Ministry of the Environment guidelines (i.e. total phosphorus - 1 mg/l or less; BOD_5 - Aurora 300 lbs/day, Newmarket 100 lbs/day).

(e) All unauthorized municipal or industrial wastewater discharges should be directed to municipal sewerage facilities.

(f) All new communities or expansions to existing communities located in the tributary basins must collect and treat urban storm drainge if it is determined that this type of wastewater discharge will impair quality or use in downstream reaches or in Lake Simcoe.

Existing municipalities, where storm water treatment may not be practicable, should minimize the impact of storm water drainage by employing good housekeeping practices as outlined in recommendation 1.2.2 (d).

(g) Municipal discharges to the marshy, headwater areas with limited assimilation capacities to the south and east of Lake Simcoe should not be permitted.

1.2.4 Material Inputs from Diffuse Sources

(a) All cottagers, individually, or through cottagers associations or other groups should inspect their waste treatment systems to ensure that they meet the Ontario Ministry of Environment specifications. The Ministry will provide technical guidance in this regard.

(b) Direct snow disposal should not be permitted to Lake Simcoe or its tributary streams.

(c) Farmers should ensure that runoff from barnyards, manure piles, silos, etc. does not gain access to the rivers or lake. They should minimize soil and fertilizer losses through proper land management techniques.

(d) Conservation Authorities or other agencies responsible for erosion control should provide adequate stream bank or shoreline protection in areas where significant erosion is occurring to minimize the input of suspended solids and other materials to the lake basin.

(e) Marina operators should construct their fuelling facilities in such a manner as to ensure that gasoline and oil will not gain access to the water. Convenient containers should be provided for the use of boaters to discourage littering.

Potential pollutants from other marina oriented activities (i.e. test tank water, repair shop floor washing, etc.) should be directed to adequate treatment facilities.

(f) Boaters should make every effort to minimize pollution from boating operations by adhering to Ontario Ministry of the Environment waste disposal regulations, providing suitable containers for litter, and keeping engines tuned to minimize the unnecessary wasting of fuel.

1.2.5 Marine Construction

(a) Development projects involving activity in shallow water areas or marsh land and activities affecting water currents, should be carefully evaluated in light of protecting fish habitat and spawning areas. The Ministry of Natural Resources can provide assistance in evaluating the effects of these projects on fish life.

(b) Marine construction and dredging activities in the basin must be conducted in accordance with the Ontario Ministry of the Environment - Dredging and Marine Construction Guidelines to protect water quality and aesthetics and to prevent interference with normal water uses.

CHAPTER 2 - DESCRIPTION OF THE SURVEY AREA

2.1 BASIN DESCRIPTION

Lake Simcoe is Southern Ontario's largest body of water, excluding the Great Lakes. With a surface area of 725 square kilometers (280 square miles), the lake has a regular shoreline of 232 kilometers (144 miles) which includes the periphery of its seven islands. Situated at an elevation of 220 meters (720 feet) above sea level, Lake Simcoe is 145 kilometers (475 feet) higher than Lake Ontario and 43 meters (141 feet) higher than Georgian Bay. The lake's average depth is 17 meters (56 feet) with a maximum recorded depth of 41.5 meters (136 feet) in Kempenfelt Bay.

Lake Simcoe's 3,125 square kilometer (1,200 square mile) watershed area is drained by 35 tributary rivers with the largest streams located in the southern and eastern portions of the watershed. These rivers include the Holland, Black, Pefferlaw, Beaverton and Talbot. In the basin's northern and western reaches, the watershed closely parallels the shoreline. Consequently the streams that flow to the lake from these areas are small. Drainage areas and average yearly flows at the five largest tributaries are illustrated in Table 2.1. A map of Lake Simcoe showing major tributaries and municipalities is presented in Figure 2.1, and a map showing the lakebed contours is presented in Figure 2.2.

TABLE 2.1 - MAJOR TRIBUTARIES TO LAKE SIMCOE

Stream	Drainage Area Sq.K.	Drainage Area Sq.Mi.	Average Annual Streamflow (cfs)	Period of Record (yrs)
Holland R.	604	232	130	9
Black R.	342	131	80	5
Pefferlaw Bk	378	145	126	5
Beaverton R.	286	110	100	8
Talbot R.	378	145	145 (est)	-
Outflow at "The Narrows"	3125	1200	830 (calc)	12

Lake Simcoe is drained through "The Narrows" at Atherley to Lake Couchiching and ultimately to Georgian Bay via the Severn River. The lake is an important link in the Trent-Severn waterway which connects Lake Ontario at Trenton to Georgian Bay at Port Severn.

Various soil conditions reflect a multitude of land uses found within the basin. The range of conditions and uses includes non-productive marshlands and gravel deposits in Georgina Township, to relatively productive agricultural areas west of Cook Bay and the Beaverton area, and to highly productive organic muck in the Holland Marsh area south-west of Cook Bay.

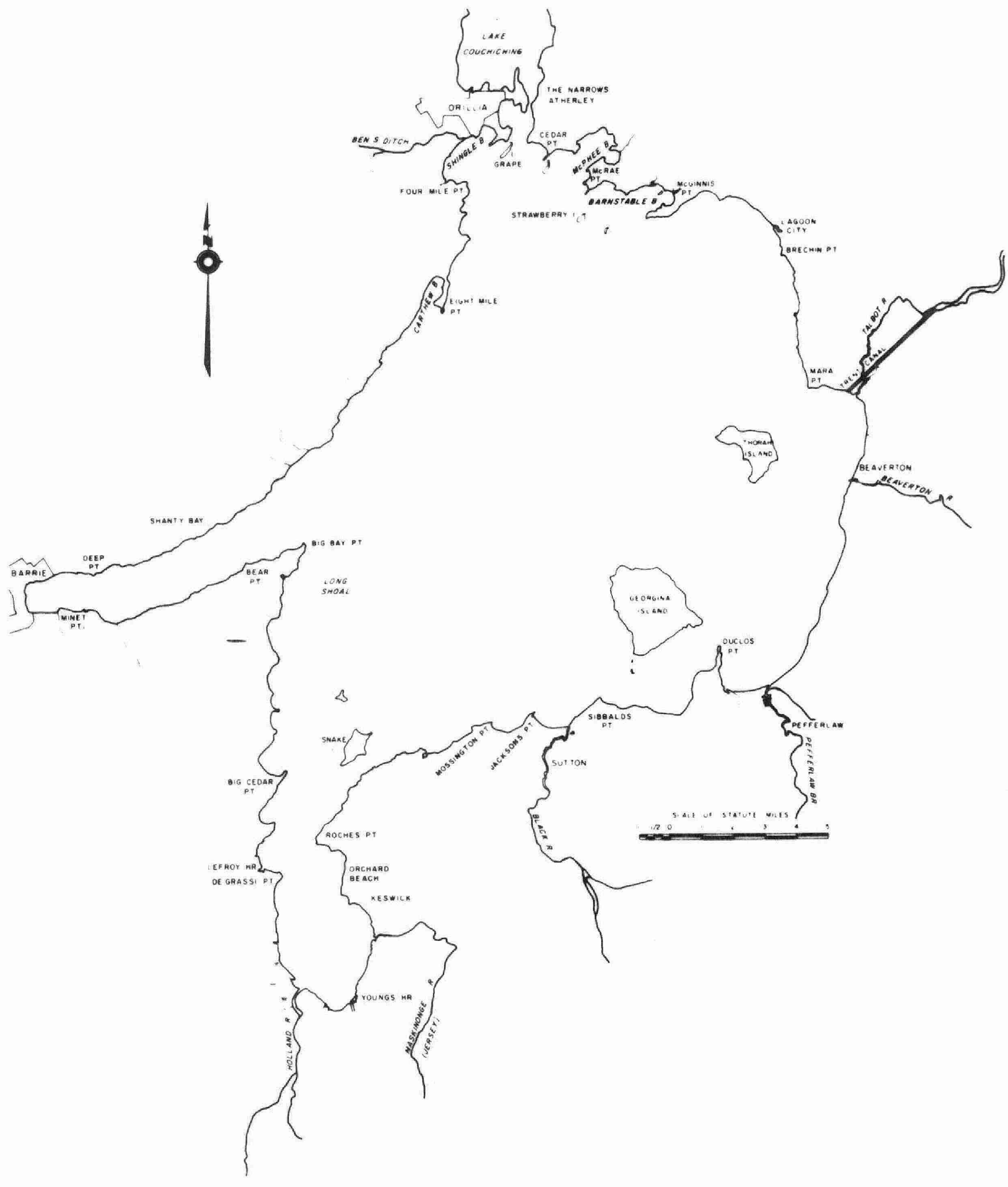

FIG. 2.1 LAKE SIMCOE, MAJOR TRIBUTARY STREAMS AND ADJACENT MUNICIPALITIES

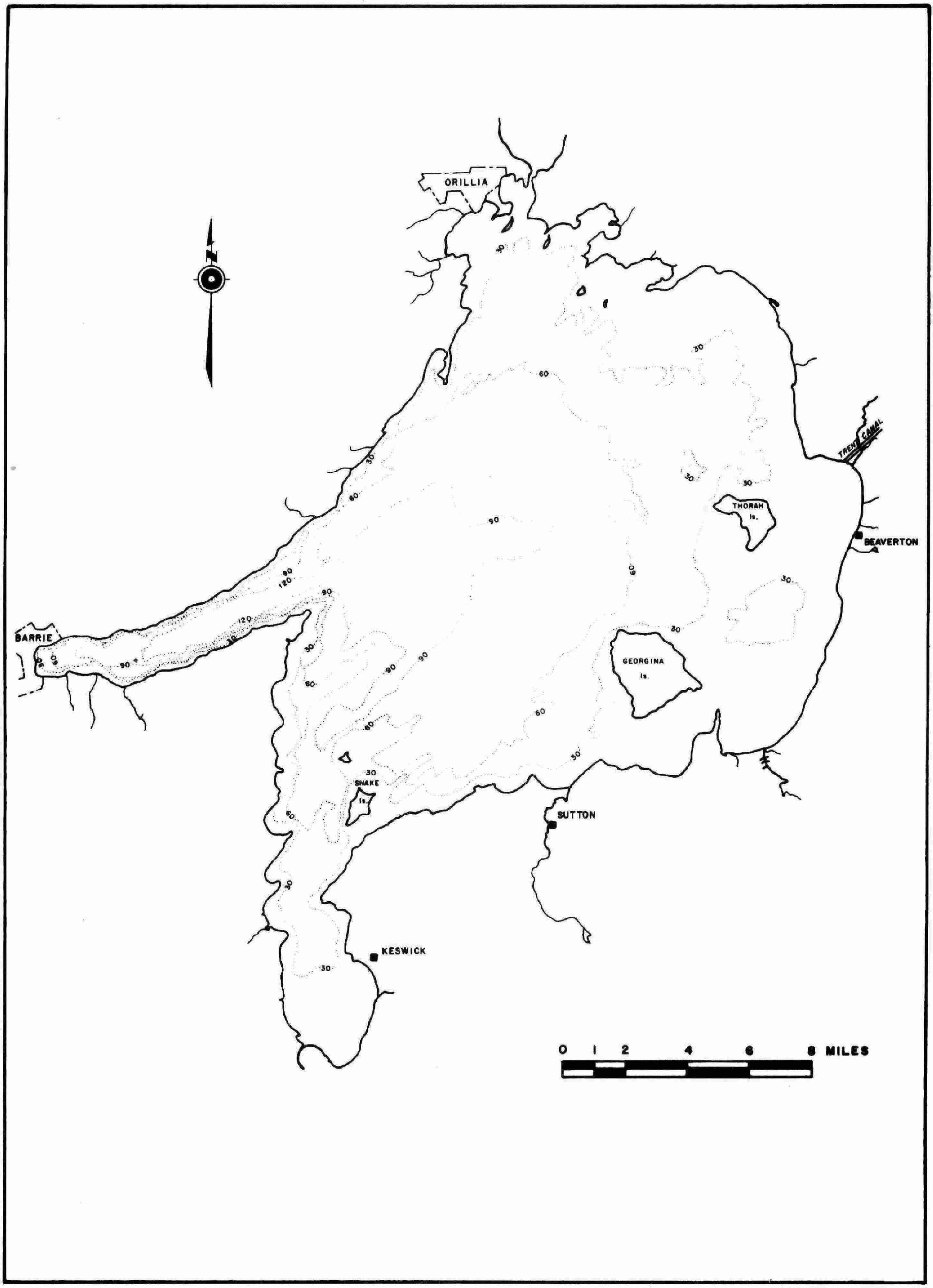

FIG. 2.2 LAKEBED CONTOURS in FEET

2.2 POPULATION CENTRES

The major municipalities located on the shoreline of Lake Simcoe and their populations (TEIGA, 1975) are:

Barrie	- 31,389 people
Orillia	- 24,014
Beaverton	- 1,400 *(e)*
Sutton	- 1,800 *(e)*

Other major population centres located on tributaries to Lake Simcoe are:

Holland River Basin	- Newmarket	- 22,736
	Aurora	- 13,631
	Bradford	- 4,170
	Holland Landing	- 1,700 *(e)*
Pefferlaw Brook Basin	- Uxbridge	- 3,200 *(e)*
Beaverton River Basin	- Cannington	- 1,200 *(e)*

In addition to these centres about 10,000 cottages with an estimated seasonal population of 40-50,000 people are located around the lake. Highest cottage densities are found around Cook Bay and along the south shore of the lake.

2.3 WATER USES

2.3.1 Recreation

Lake Simcoe, with its proximity to the Golden Horseshoe area with a population of over three million people, is used extensively for recreational purposes. Many people from these centres own or rent cottages on the lake and a great many more camp and make day use of the lake's parks and campsites.

In addition to swimming, the prime recreational use, many vacationers use the lake for boating and water-skiing. Thirty-five marinas around the lake provide boat docking, fuel, pump-out, and other service facilities. Because of its connection to the Trent-Severn system, the lake is homebase for a large number of yachts.

Lake Simcoe supports a good cold and warm water fishery. Fishing is very popular in summer and winter for pleasure and limited commercial fishing. Fish caught in abundance range from lake trout and whitefish to bass, pickerel, and pike. Lake Simcoe is the most popular ice-fishing centre in Ontario for lake trout and whitefish.

(e) Estimated only, exact population figures not available

With the advent of the snowmobile, winter recreation in the Lake Simcoe basin is constantly increasing. Winter carnivals are becoming common occurrences on the lake.

2.3.2 Water Supply

Many cottagers use the water from Lake Simcoe for washing and bathing. Some also use the lake for drinking and cooking water supply after providing some form of treatment. The villages of Beaverton and Sutton, Sibbald Point and McRae Point Provincial Parks and the Briars Inn, east of Jackson's Point all take their water from the lake for domestic use. The municipalities of Keswick and Orillia are currently conducting studies to determine the feasibility of using lake water for their municipal supply.

2.3.3 Waste Disposal

Nine municipal sewage treatment plants discharge treated wastewater either directly to Lake Simcoe or to tributary streams. All plants provide secondary type treatment and, as of 1974, include phosphorus removal as part of their treatment. A tabulation of sewage treatment facilities and outfall locations is provided in Table 2.2.

In total about 90,000 people are served by the nine plants; expansions are planned for several of these facilities in the near future. Several new sewage treatment facilities are also currently being considered in the Lake Simcoe basin. These include Keswick, Holland Landing, the Lagoon City-Brechin area and Innisfil Beach.

2.4 DEVELOPMENT WITHIN THE LAKE SIMCOE BASIN

The Lake Simcoe basin is currently experiencing a tremendous growth rate, especially the areas which are within commuting distance of Metropolitan Toronto. In fact, the area from Barrie southward is receiving the most intense pressure due to the excellent road systems servicing this area, a recently inaugurated commuter transit service, and the availability of attractive land for urban development.

The City of Barrie from 1961 to 1971, has experienced a growth rate of 2.7 percent per year. More recent figures indicate that this City is expanding at a much more rapid rate. The population was estimated in early 1974 at approximately 30,000. Population estimates of up to 80,000 people have been predicted for Barrie by the year 2000.

Innisfil Township, south of Barrie, has grown over the past decade at an annual rate of about four percent and is currently the portion of the lake basin that appears to be most favoured for new, major urban development. The present permanent population of the area is about 12,000. Reliable population projections for the area are not available but it

TABLE 2.2

MUNICIPAL DISCHARGES TO THE LAKE SIMCOE BASIN - 1974

Municipality	Plant Capacity and Treatment Provided	Outfall Location
Barrie	3 MIGD activated sludge with chemical phosphorus removal	Discharges via a submerged outfall to the western end of Kempenfelt Bay
Orillia	4 MIGD activated sludge with chemical phosphorus removal	Discharges to a small watercourse which drains to Shingle Bay
Beaverton	28-acre lagoon with batch addition of chemicals for phosphorus removal	Seasonal (spring and fall) discharges via a 3600 foot outfall to Lake Simcoe
Sutton[1]	16-acre lagoon with chemical phosphorus removal	Continuous discharge to the Black River downstream from Sutton
Aurora[1,2]	1.8 MIGD activated sludge with chemical phosphorus removal	Discharges to Aurora Creek (Holland) River (in Aurora)
Newmarket[1,2]	2 MIGD activated sludge with chemical phosphorus removal	Discharges to the Holland River downstream from Newmarket
Bradford[1]	0.8 MIGD activated sludge with chemical phosphorus removal and a lagoon system	Discharges to the West Holland (Schomberg) River
Uxbridge	0.5 MIGD trickling filter with chemical phosphorus removal	Discharges to the Uxbridge Brook (Pefferlaw Brook)
Cannington[1]	14.5-acre lagoon with batch addition of chemicals for phosphorus removal	Seasonal (spring and fall) discharges to the Beaverton River

1. Expansions to the municipal sewage treatment facilities are currently being planned.

2. Wastewater discharges from these sources may be directed to the York - Durham Provincial Sewage Works with ultimate discharge to Lake Ontario.

is expected that in the next few years the population may expand several-fold.

The aforementioned transit service between Toronto and Barrie will also serve communities south of Barrie such as Bradford, Holland Landing, Newmarket and Aurora providing additional impetus for development in these areas. It appears quite conceivable that the populations in these communities could increase substantially within the next few decades.

The City of Orillia is not slated as a growth centre as far as the Toronto Centred Region Plan is concerned. Population increased from 1961 to 1971 at about 1.8 percent per annum. The 1974 population of Orillia is about 22,500. The north-western and northern shorelines of the lake are not expected to expand as rapidly as most other areas of the basin.

The eastern and south-eastern shores of Lake Simcoe will receive some incentive for development as Hwy. 404 is planned to be constructed north from Toronto and along the south-east and east shores of Lake Simcoe to the Muskoka recreational area. The municipalities of Keswick (Georgina Township), Sutton, Uxbridge, Beaverton, Brechin-Lagoon City and a number of smaller communities in the southern and eastern sectors of the Lake Simcoe basin are all expected to grow significantly over the next few years.

The trend to converting cottages to year-round homes is also occurring in the Lake Simcoe Basin. Studies conducted in Georgina Township by the Planning Department of the Regional Municipality of York indicates that the annual rate of conversion of cottages to permanent residences is between three and four percent.

CHAPTER 3 - COTTAGERS' QUESTIONNAIRE

The Ministry of the Environment, in co-operation with the Ministry of Natural Resources, developed a cottagers' questionnaire to solicit public opinion on environmental quality, resource use, development and management of the Lake Simcoe basin.

3.1 POLLING METHOD

After a review of a number of general public survey methods, it was determined that the best way to reach the cottagers on or close to Lake Simcoe was through a postal distribution of questionnaires. The mailing list used was a "seasonal residential billing list" provided by Ontario Hydro. Approximately 1,200 names were selected at random from the billing areas in closest proximity to the lake (Sutton, Markham, Barrie, Orillia and Fenelon Falls) and questionnaires were sent to the permanent address of those selected.

A total of 571 completed questionnaires were returned, providing a 48 percent response. Because regional billing lists were employed, a number of returned questionnaires were from outside the Lake Simcoe basin. The total number of completed questionnaires of value in this poll was 347, approximately three percent of the Lake Simcoe population.

The results were tabulated using System/360, Generalized Information System (GIS). For the purpose of this report, tabulation was in the form of simple totals and averages without detailed cross-correlation of data.

In the following sections, highlights of the questionnaire are presented.

3.2 GENERAL INFORMATION

Cottage development and use on Lake Simcoe is well established and stable as evidenced by the fact that over 80 percent of the cottages are greater than 10 years old and 75 percent of these cottages have been owned by one person or family for at least 10 years.

On the average, Lake Simcoe cottages are used about 90 days per year and the average number of people using each cottage ranges from four to five. Eighty-five percent of the cottage owners use their cottages on weekends, 70 percent spend their family vacation on the lake and over 30 percent use their cottages on week days other than during family vacations. Forty percent of the cottagers either use or intend to use, their cottages during the winter months.

The strongest reason for purchasing or utilizing cottages on Lake Simcoe appears to be the accessibility to the lake, i.e. it is within a 1-2 hour drive from the Toronto-Hamilton area via modern highways and good secondary roads. Other reasons cited included: environmental considerations of clean water

and air; the wide recreational potential of the lake and the various social activities of the cottagers (e.g. golf clubs, dances, regattas, cottagers' associations, etc.).

3.3 WATER USES

3.3.1 Water Supply

Drinking water is obtained directly from the lake by 22 percent of the cottagers, 57 percent have wells, 13 percent use a municipal distribution system and eight percent use springs or other sources. Fifty-two percent, likely those on municipal systems and some wells, provide no form of treatment before use. The rest, filter, chlorinate or boil their drinking water.

3.3.2 Waste Disposal

Eighty-three percent of the cottagers dispose of toilet wastes in a septic tank with tile field systems, 10 percent use pit privies and the remainder use combustion units, chemical toilets, holding tanks or seepage pits. Sink and bath wastes are disposed of to septic tanks, seepage pits, or directly onto the ground. Only 14 percent do their laundry at their cottages. Waste water from this source is primarily directed to the septic tank systems, seepage pits or onto the ground. Only 10 percent of those polled, plan to change their waste disposal systems in the near future and most of these people indicate they will be converting to septic tanks with tile field systems.

3.3.3 Recreation

Eighty percent of those people who answered the questionnaire feel that the Lake Simcoe area can be rated as good to excellent for recreational purposes. Only 4 percent classify the lake as poor or very poor for recreational pursuits.

Swimming appears to be the most popular activity. Three-quarters of those people polled rank this as their first preference. Other popular recreational activities in order of preference are power boating, fishing, water skiing, sailing, canoeing and snowmobiling.

Specifically relating to boating, the questionnaire showed that 70 percent of the cottagers own or rent boats. Over 80 percent of those people use outboard motor boats, about 30 percent use canoes and rowboats, 20 percent sail and about 10 percent own inboard cruisers.

The fact that only about 70 percent of Lake Simcoe cottagers own boats is quite interesting. In a similar questionnaire prepared for the Kawartha Lakes, 90 to 100 percent of the cottagers owned boats. The difference probably lies in the fact that there are a large number of cottages in the Lake Simcoe area which are not located directly on the lake. The trouble and expense of keeping a boat at a marina, possibly some distance away, likely outweighs the advantages of boating

to many people. In addition Lake Simcoe is often too rough for small boats and during storms can be very treacherous.

A portion of the questionnaire was devoted to fishing. It was found that about 60 percent of the cottagers fish. About two-thirds of the fishermen expressed the concern that the fishery of Lake Simcoe is declining, 30 percent felt that there is no significant change and less than 5 percent felt that fishing is improving.

Although the questionnaire did not explore in detail the prevailing attitude that fishing in Lake Simcoe is declining, it appears that the fishermen are catching more of the less desirable species such as perch, smelt and pan fish and fewer of the preferred fish such as lake trout and whitefish. The fishery of Lake Simcoe is described in more detail in Chapter 8.

The cottagers were asked for recommendations for improving the recreational qualities of the Lake Simcoe area. Some of the more common responses to the question were: provide more recreational facilities (13 percent), improve water quality (12 percent), preserve the natural features of the area (10 percent), increase fish stocking (9 percent), control septic tank drainage (8 percent), control cottage development (7 percent), control biting insects (6 percent), improve beaches (6 percent), provide stricter laws to curb pollution (6 percent), control littering (5 percent), control power boat speed (4 percent).

3.4 ENVIRONMENTAL QUALITY

From the foregoing paragraph, it is interesting to note the Lake Simcoe cottagers concern for the environment, i.e. improve water quality, control septic tank drainage, stricter pollution laws, control littering, etc. One section of the questionnaire was related specifically to environmental considerations with particular emphasis on water quality.

Sixty percent of the cottagers feel that the quality of Lake Simcoe has changed over the past five years. The principal areas of concern are illustrated in the following table.

Table 3.1

Environmental Quality Considerations in the Lake Simcoe Basin

	Considered A Problem	Increasing	Decreasing	No Change
Algae Growth	41%	53%	1%	18%
Littering	40	47	1	19
Boat Noise	37	37	3	16
Water Colour	28	31	2	30
Motor Boat Oil and Gas	25	42	1	22

	Considered A Problem	Increasing	Decreasing	No Change
Water Level Variation	20	17	3	33
Foaming or Sudsing	19	30	3	23
Cottage Development	17	53	0	18
General Noise Level	17	46	0	20
Water Weeds Washing Ashore	14	25	2	28
Weed Growth in Lake	12	22	2	34
Odours	10	14	0	35
Wildlife Abundance	7	2	32	29

CHAPTER 4 - SURVEY PROCEDURES AND METHODS

4.1 FIELD INVESTIGATIONS

During the intensive Lake Simcoe Basin survey period, 1971-74 a number of different types of field studies were carried out on the lake proper and in the tributary basins. In the following section, the purposes and general procedures of each type of field investigation are presented.

4.1.1 Routine Surveillance

(a) Lake

In May 1971, a water quality monitoring program was established at 45 locations throughout the lake (Fig. 4.1). During ten runs that year (from May to November), dissolved oxygen and temperature vertical profiles were measured. Samples were collected in the epilimnetic and hypolimnetic zones for total and soluble reactive phosphorus, free ammonia, total kjeldahl, nitrite, nitrate, turbidity, pH, iron, conductivity, hardness, carbon dioxide and alkalinity. Water clarity was measured using a secchi disc and samples were collected for chlorophyll a and b determinations. Samples were also collected at nine locations for phytoplankton analysis. Surface and depth samples for total coliform, fecal coliform and fecal streptococcus enumeration were also collected at each station. Brief descriptions of sampling and analytical procedures are presented later in this chapter.

The results of the 1971 monitoring program were reviewed and for the 1972 survey operations, the number of sampling locations was reduced to 24 stations. Procedures and parameters were virtually unchanged from the 1971 program. Seven sets of data were collected.

In 1973 and 1974, sampling stations were reduced to 13 key locations and analyses were limited to dissolved oxygen and temperature profiles, secchi disc, total and soluble reactive phosphorus, free ammonia, total kjeldahl, nitrite and nitrate, pH, turbidity and chlorides. Samples were collected monthly from May to October.

(b) Tributary Streams

Through the Ministry of the Environment's routine water quality monitoring program, major streams in the Lake Simcoe Basin have been sampled since 1964. Early in 1972, the network was expanded to include all other significant water courses draining to the lake. A total of 15 rivers and streams are sampled near their mouths, and a number of rivers are also sampled at upstream locations usually in the vicinity of municipal STP outfalls or other pollution sources. All stations are sampled monthly with intensified sampling during the spring runoff period. Water quality analyses includes dissolved oxygen, temperature, BOD_5, total and soluble reactive phosphorus, total kjeldahl, free ammonia, nitrite and nitrate, total and suspended solids, turbidity, conductivity,

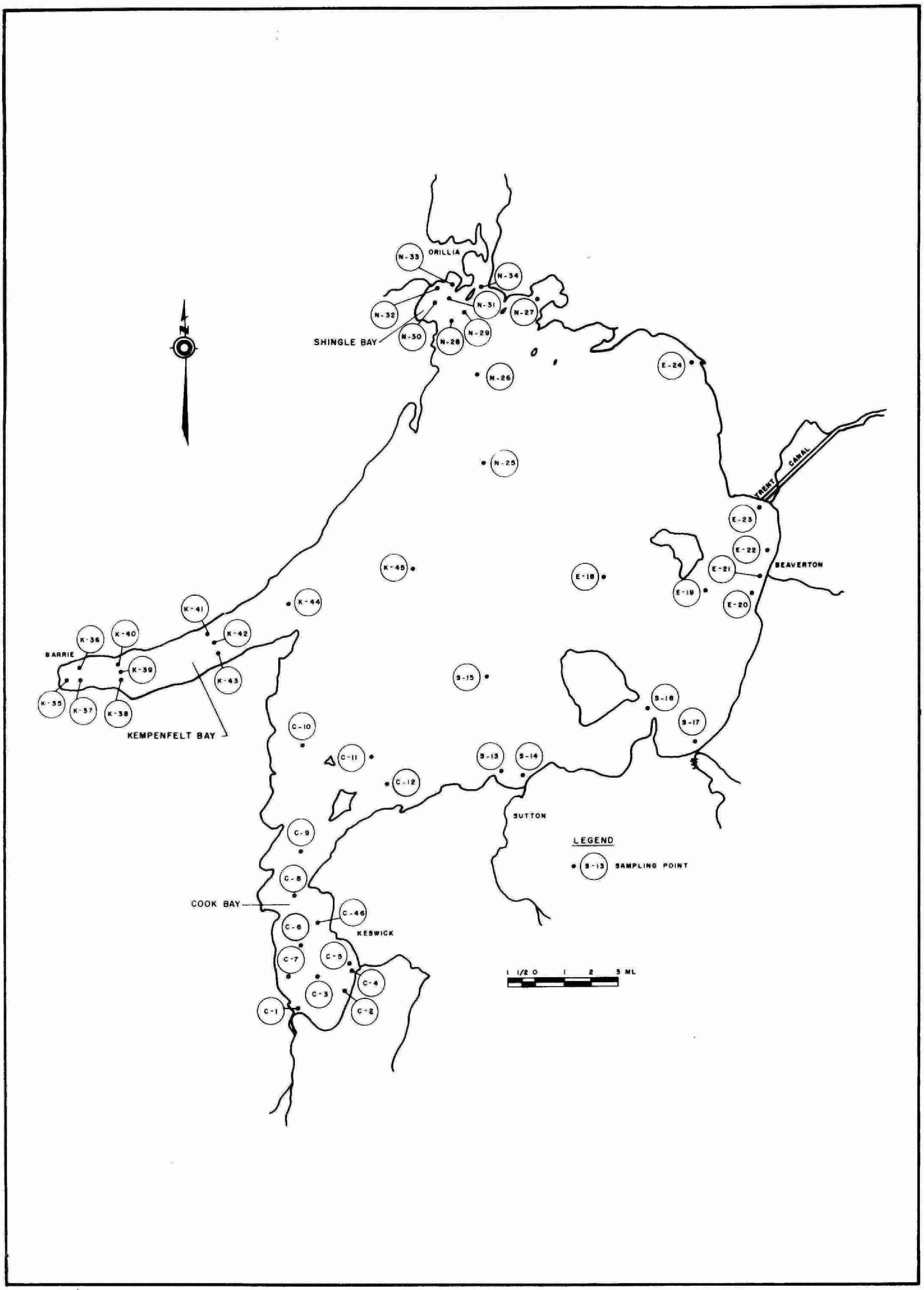

FIG. 4.1 LAKE MONITORING STATION LOCATIONS

chlorides, phenols, and the bacteriological parameters total and fecal coliforms and fecal streptococcus. Streamflow information is available from gauges located within the river basins or can be extrapolated from data collected on nearby streams.

4.1.2 Intensive Water Quality Surveys

(a) Lake

During 1971 and 1972, intensive water quality studies were conducted in several areas of the lake, adjacent to municipal sewage treatment plant outfalls and major tributary streams. Brief descriptions of the purposes and procedures and these studies are presented in the following paragraphs.

Cook Bay: Three intensive 24 to 48-hour, around-the-clock, water quality studies were conducted in Cook Bay during 1971 and two similar studies were conducted during 1972. The principal purpose of these investigations was to measure the magnitude and effects of material inputs from the Holland and Maskinonge rivers on the quality of Cook Bay. During each survey, dissolved oxygen and temperature profiles were measured at 32 to 48 stations. Nitrogen, phosphorus, and bacteriological samples were collected at each station during each study and samples for BOD_5, pH, turbidity, hardness, conductivity, and chlorides were collected during at least one intensive survey each year. Water current studies were also conducted using drogues in an effort to establish current patterns in the vicinity of the mouth of the Holland River and southern Cook Bay.

Kempenfelt Bay: Three intensive 24 to 48-hour water quality studies were conducted in Kempenfelt Bay during 1971 and two similar studies were carried out in 1972 to assess the magnitude and effects of wastewater discharges from the City of Barrie STP, and other sources in the area on the water quality of Kempenfelt Bay. During the first survey in 1971, sampling stations were located throughout the bay and extended into the open water area of the lake. An evaluation of the data collected during this survey indicated that during subsequent studies, activities could be restricted to the western half of Kempenfelt Bay. During each of the five surveys over the two years, vertical dissolved oxygen and temperature profiles were measured and samples for nitrogen and phosphorus analysis were collected from the epilimnion and hypolimnion. Surface samples for bacteriological analysis were collected at each station. Samples for laboratory analyses of BOD_5, total solids, turbidity, conductivity, pH and chlorides were collected during at least one sampling survey each year to complement routine lake monitoring data. During August 1972, deep drogues were deployed in an effort to determine current patterns in the west end of the bay.

Shingle Bay: One intensive water quality study in 1971 and two similar surveys during 1972 were carried out in Shingle Bay to assess the effects of treated effluent from the City of Orillia STP on water quality. During the three studies,

dissolved oxygen and temperature measurements were taken at each station with vertical profiles in those areas of the bay over 15 feet deep. During the 1971 survey, samples were collected for phosphorus and nitrogen analyses at each station. During the 1972 surveys, additional samples were collected for BOD_5, turbidity, pH, conductivity, chlorides and bacteriological analyses.

River Mouths: In addition to intensive studies in the three major bays described in the preceding paragraphs, studies were conducted during 1972 in the vicinity of the following major river outlets: the Holland River, the Maskinonge River, the Black River, Pefferlaw Brook, the Beaverton River and the Talbot River-Trent Canal. The purpose of these studies was to measure the effects of material inputs from the rivers on the quality of the adjacent areas of Lake Simcoe.

Samples were collected at the rivers' mouths and at semi-circular arcs radiating at ranges of 100, 250, 500 and 1000 meter intervals from the mouths. Analyses at all stations in each survey included phosphorus , nitrogen, conductivity and chlorides. The rivers and the ranges nearest the mouths were also sampled for BOD_5, and bacteriological analyses.

Bottom Fauna: Samples were collected from the lakebed using a Ponar dredge at each of the 45 lake monitoring stations plus an additional 18 locations. Each sample was passed through a 0.65 mm aperture sieve; the organisms were placed in jars and taken to the MOE laboratories for identification and enumeration.

Sediment Sampling: Sediment samples were collected using a Ponar dredge at a total of 92 locations throughout the lake and analyzed for organic content (percent loss on ignition).

Spawning Shoals: Several of the spawning shoals were investigated for sedimentation problems and periphyton coverage using divers with SCUBA equipment.

Aquatic Weed Assessment (Macrophytes): During July and August of 1971, 143 locations through the lake were investigated for macrophytic growths. Intense investigation was given to those areas where weed growths were most abundant, i.e. Cook Bay, Shingle Bay, and Kempenfelt Bay.

At each location, divers using snorkelling or SCUBA gear retrieved and identified samples in a 15 foot radius of the boat. Each species present within the circle was recorded and the abundance of individual species was determined by estimating their respective densities.

An estimate was made at each station of the percent of the bottom covered by macrophytes. Periodic checks were also made on the maximum depth to which growth occurred.

Echo Tracings: A Furuno Model FG200 portable echo sounder was used to obtain tracings of the lake profile at three transects in Kempenfelt Bay in an effort to determine the vertical

location of fish during the late summer stratification period when dissolved oxygen levels in the hypolimnetic waters are depleted to levels considered unacceptable for cold water fishery habitation. Fish or schools of fish show up as marks on these graphs indicating the location of the fishes. In total, ten passes were made at the three transects.

(b) Tributary Streams

During the summer of 1972, intensive water quality investigations were conducted in four of the major river basins draining into Lake Simcoe. The principal purposes of these studies were to measure the current water quality status, determine the significance and magnitude of inland pollution sources, and to generally catalogue land uses within the basin. Brief descriptions of each of the river basin studies are presented in the following paragraphs.

Holland River: Two studies were conducted in the Holland River Basin during July 1972. The first, a 72-hour, around-the-clock, investigation of the East Branch, extended from Aurora to the mouth of the river at Cook Bay. Of prinicpal interest during the survey were those areas of the basin downstream from the towns of Aurora and Newmarket and the lower river which flows through a highly productive marsh area, north of the community of Holland Landing, on the East Branch, and north of the Town of Bradford, on the West Branch. Thirty-one stations were sampled eight times during the 72-hour study and analyses included dissolved oxygen, temperature, total and fecal coliforms, fecal streptococcus, BOD_5, chlorides, total solids, phosphorus and nitrogen.

The second survey was a 24-hour study of the West Holland River (formerly called the Schomberg River) with the study reach extending from the headwater area near the community of Lloydtown, downstream to the Town of Bradford. Principal areas of interest in this investigation were the Community of Schomberg and the intensively developed muck farming area of the Holland Marsh. Eighteen stations were sampled twice for dissolved oxygen, temperature, total and fecal coliforms, fecal streptococcus, BOD_5, turbidity, phosphorus, and nitrogen Bottom fauna were also identified and enumerated at 25 locations throughout the basin.

Maskinonge River: Intensive water quality investigations of the Maskinonge River were conducted during May and September, 1972. Aside from some private farming operations, the principal area of interest in this basin is the Village of Keswick. During each survey, 17 stations were sampled for dissolved oxygen, temperature, total and fecal coliforms, fecal streptococcus, BOD_5, nitrogen and phosphorus.

Pefferlaw Brook: On July 31 and August 1, 1972, intensive water quality sampling was conducted at 18 stations in the Pefferlaw Brook Basin. The bulk of survey effort was expanded in the river reaches downstream from the communities of Pefferlaw and Uxbridge. Dissolved oxygen and temperature were measured at each station and samples were collected for BOD_5 ,

nitrogen, phosphorus, total solids, turbidity, total and fecal coliforms, and fecal streptococcus analyses. Samples for chromium, copper, nickel and zinc analyses were collected from Uxbridge Brook to measure residual effects from a metal plating industry in Uxbridge, which ceased operations in early summer 1972. Bottom fauna was also investigated at 13 locations within the basin.

Beaverton River: Thirteen stations on the Beaverton River Basin were sampled on August 8, 1972, with primary emphasis placed on those areas of the watercourse in the vicinity of the municipalities of Beaverton, Cannington and Sunderland. Additional sampling was carried out at the Sunderland stations during a period of ice cover in February 1973 and during spring runoff in March 1973. Dissolved oxygen and temperature were measured at each station during each sampling run and samples were collected for BOD_5, phosphorus, nitrogen, total solids, turbidity, total and fecal coliforms, and fecal streptococcus.

4.1.3 Miscellaneous Surveys

(a) Intensive Shoreline Water Quality Surveys

During May and September, 1972, an intensive nearshore sampling program was conducted around the complete shoreline of Lake Simcoe. Samples were collected as close to shore as possible, usually within 25 meters of shore and analysed for total coliform, fecal coliform, fecal streptococcus, nitrogen and phosphorus. Shoreline development and uses were also catalogued. The purpose of this investigation was to try to determine the significance and effects of intensive recreational and sustained cottage uses on nearshore water quality. The spring sampling run was conducted prior to summer use of the cottages and recreational facilities, and the September sampling period followed closely the termination of the summer vacation period. Similar surveys were conducted during 1973 to confirm the previous years findings.

(b) Oxygen Uptake Rates of Lake Bottom Sediments

In the autumn of 1972, undisturbed cores from several locations throughout Lake Simcoe were collected to determine the rate of oxygen utilization during the stabilization of organic lake sediments. Dissolved oxygen in the water column overlying the sediment was measured at the start of the test and separate samples of the same water were placed in air-tight containers to determine the BOD of the overlying water. Both the core and the BOD samples were placed in an ice bath and the temperature during the test was maintained at or near the temperature actually measured at the lake bottom. After a number of hours the dissolved oxygen levels of the water in the core tubes and BOD bottles were measured. The total oxygen loss in the core tube, "delta", was determined by substracting the test end DO concentration from the level measured at the start of the test. The loss of oxygen in the BOD bottle was determined in the same manner and subtracted from the "delta" value. The remaining deficit was attributed

to benthic respiration. The rates thus measured were converted to the convenient term grams of oxygen per square centimeter per day and applied appropriately to the measured areas of sediment in Lake Simcoe to determine the total annual oxygen loss through decomposition of the sediments.

4.2 PARAMETER MEASUREMENT AND ANALYTICAL PROCEDURES

4.2.1 Field

a) Dissolved Oxygen - Temperature: Dissolved oxygen measurements were recorded in the field using electronic dissolved oxygen-temperature meters (Yellow Springs Instruments, Model 54 and EIL models 15A and 1521). The meters were calibrated regularly during the day using the Azide modification of the Winkler method for dissolved oxygen and mercury thermometers for temperature.

In the shallow areas of the lake, (less than 5 meters) dissolved oxygen and temperature measurements were taken one meter below the surface. In the deeper areas of the lake, dissolved oxygen and temperature measurements were taken at 10 percent intervals through the vertical profile.

b) Carbon Dioxide: Samples for free carbon dioxide analysis were collected one meter below the surface in 6-ounce bottles and analysed within six hours in the field using a Hach CO_2, kit and an Analytical Measurements portable pH meter. The pH meter was standardized at regular intervals using buffer solutions prepared by the Ontario Ministry of the Environment laboratories.

c) Secchi Disc: Secchi disc readings, measurements of water clarity, were obtained at every station where the lake bottom was not visible to the naked eye. A nine inch circular steel disc painted black and white in alternating quadrants was lowered into the water on a graduated line until the disc disappeared. The depth of disappearance was noted. The disc was lowered further, then slowly raised until it reappeared; this depth was also noted and an average of the two depths was recorded as the Secchi disc reading.

d) Phytoplankton and Chlorophyll: Samples for chlorophyll and phytoplankton analyses were collected at selected stations during the routine lake sampling surveys. The sample collection procedure involved determining the secchi disc depth and then lowering two 32 ounce glass bottles in a weighted container to two and one-half times the secchi disc depth (i.e. the euphotic zone). The sampler was lowered and then raised at a uniform speed so the bottles would just be filled as the sampler was pulled from the water. One bottle for chlorophyll analysis was fixed with 15 drops of a 2 percent solution of magnesium carbonate, the second bottle, for phytoplankton analysis was fixed with Lugol's iodine. Both samples were submitted to the Ministry of the Environment laboratories for analysis.

e) Chemical and Physical: Surface water samples (i.e. samples collected within one meter of the surface) were collected in stainless steel sampling buckets and depth samples were collected in three litre brass Kemmerer samplers. Most samples submitted for routine chemical and physical analysis (i.e. BOD_5, nitrogen, phosphorus, solids, turbidity, conductivity, chlorides, etc.) were then placed in 32 ounce Boston round bottles. Samples for phenols analysis required 6 ounce glass bottles fixed with copper sulphate. Samples for heavy metal analyses required 20 ounce plastic bottles fixed with ten drops of nitric acid or other preserving agents. All samples were forwarded to the Ontario Ministry of the Environment laboratories in Toronto within a maximum of 24 hours from the time they were collected. Perishable samples were refrigerated immediately after sampling.

f) Bacteriological Analysis: Surface samples for bacteriological analyses were collected directly in 6 ounce sterile glass bottles and depth samples in sterile rubber bulbs using a depth sampling device designed by the Ontario Ministry of the Environment. Both the bottle and bulb samples were kept on ice when in the field and transported to the Ministry of the Environment's laboratories in Toronto within a maximum of 24 hours.

4.2.2 Laboratory Procedures

a) Chemical and Bacteriological Analytical Methods: All chemical and bacteriological analyses were performded in the Toronto laboratories of the Ontario Ministry of the Environment using methods laid out in "Standard Methods for the Examination of Water and Wastewater", or "Outline of Analytical Methods", March, 1974 prepared by the Laboratories Branch of the Ministry of the Environment.

b) Biological Methods:

Phytoplankton - Samples which had been stabilized in the field were allowed to stand to concentrate the phytoplankton cells in the bottom of the sample. A count was then made of numbers of cells per milliliter.

Chlorophyll - Field stabilized samples were analysed using methods set out in "Outline of Analytical Methods, March 1974, Ministry of the Environment".

Bottom Fauna - Samples collected in the field were identified and enumerated in the MOE laboratories.

Sediments - Organic content of the sediments was determined by measuring the loss in weight of the sample following ignition to oxidize the organic materials.

CHAPTER 5 - WATER QUALITY FINDINGS

5.1 LAKE MONITORING

5.1.1 Phosphorus[1]

The element phosphorus does not occur in its free form in nature, but is found in the form of phosphates in several minerals and is a constituent of fertile soils, plants and animal tissue. Domestic and industrial wastewater, urban and agricultural land drainage may contain high levels of phosphorus. Precipitation may also be a significant source of phosphorus in a large water body. Phosphorus is an essential plant nutrient, and in some cases, regulating the input of this material may control the growth of aquatic plants and algae.

(a) Spatial Surface Distribution

Figure 5.1 illustrates the concentration of total phosphorus in surface waters of Lake Simcoe for the years 1970 to 1973. In general, phosphorus levels in the surface waters were low and quite uniform throughout most of the lake. Total phosphorus concentrations at most stations normally ranged from .015 mg/l to .019 mg/l. It is difficult to obtain an accurate average figure for total phosphorus in the surface waters of Lake Simcoe, however, a figure of 0.017 mg/l was arrived at to compare Lake Simcoe with other lakes.

While Figure 5.1 suggests that surface phosphorus concentrations changed from one year to the next (e.g. 1973 medians are low), these differences may be the result of the limited sampling frequency. To determine possible trends in the concentration of phosphorus in Lake Simcoe would require an increased (i.e. weekly) sampling frequency over a number of years.

The uniformity of total phosphorus levels throughout most of the lake would suggest that the phosphorus loadings to the lake via rivers, waste effluents, etc. are rapidly dispersed or carried to the lake bottom. As is pointed out in Section 5.3 (Tributary River Basins), phosphorus levels in the vicinity of the river mouths decreased rapidly from river concentrations to lake concentrations.

There are three local areas in Lake Simcoe, however, where there was a build-up of total phosphorus in the surface waters. The largest and most significant area of phosphorus enrichment was Cook Bay. Very near the mouth of the Holland River, the concentration of total phosphorus was more than an order of magnitude greater than background lake levels; however, this concentration dropped off rapidly.

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[1] *Temporal fluctuations in phosphorus concentrations at several stations precluded the use of simple averages to describe general phosphorus levels in Lake Simcoe. Median phosphorus concentrations were employed.*

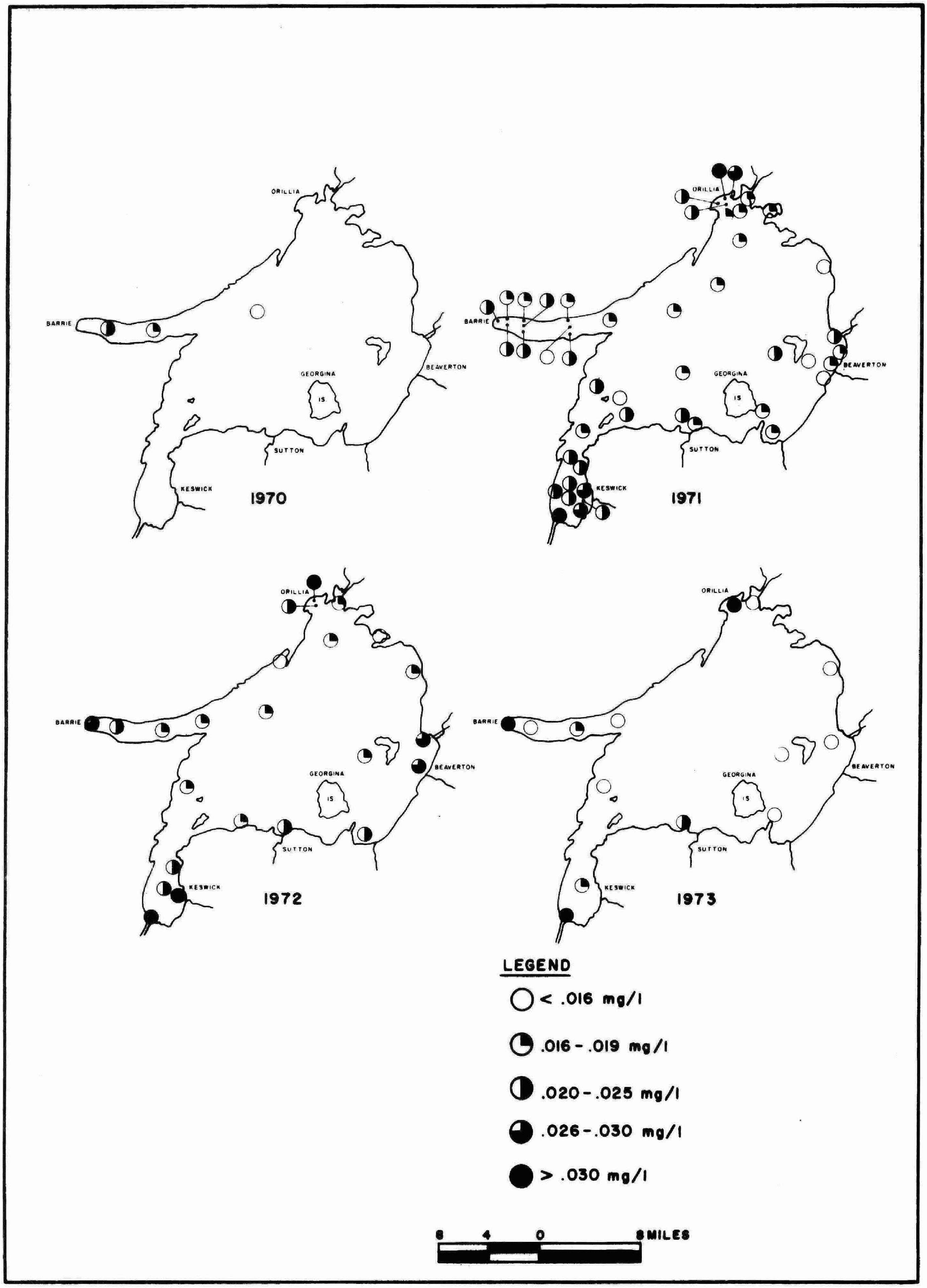

FIG. 5.1 TOTAL PHOSPHORUS CONCENTRATIONS IN SURFACE WATERS

Phosphorus levels in Cook Bay itself generally appeared to be about 50 percent higher than the open lake level. Cook Bay was obviously serving as an effective phosphorus trap; while the phosphorus loading to Cook Bay from the Holland River was large, very little of this river loading reached Lake Simcoe proper.

The second local area of phosphorus build-up was Shingle Bay. The enriched area in this case was much smaller than Cook Bay, but the severity of the resulting biological problems were comparable. The increased phosphorus levels in Shingle Bay reflected the phosphorus loadings from the Orillia Sewage Treatment Plant.

In addition, a minor build-up of phosphorus occurred in the extreme west end of Kempenfelt Bay in the vicinity of the effluent from the City of Barrie Sewage Treatment Plant. Figure 5.1 also illustrates that elevated phosphorus levels occurred at some of the near shore locations in the east and south sides of the lake.

Not unlike total phosphorus, the soluble reactive phosphorus concentrations in the surface waters were low and uniform throughout most of the lake. The soluble phosphorus medians throughout most of the lake ranged from less than 0.001 mg/l to 0.004 mg/l. At most sampling locations, the median concentration of soluble phosphorus was 0.002 mg/l which was roughly an order of magnitude lower than the total phosphorus values.

At three stations, median levels of soluble phosphorus in surface waters were above 0.004 mg/l. These stations are near the Holland River mouth, in the vicinity of Barrie STP effluent, and near the mouth of Ben's Ditch in Shingle Bay.

(b) Vertical Distribution

From the survey data it appears that there were only minor differences in concentrations between the surface and bottom waters of Lake Simcoe even during the summer stratification period. During the intensive monitoring periods of 1971 and 1972, total phosphorus concentrations in the bottom waters were only 0.004 to 0.005 mg/l higher than concentrations in the surface water. Similarly soluble reactive phosphorus levels at depth exceeded surface concentrations by only 0.001 to 0.002 mg/l.

5.1.2 Nitrogen

Nitrogen occurs abundantly in nature constituting nearly 80 percent by volume of the atomosphere. It is present in mineral deposits and is an essential constituent of living organisms. In organic matter it can undergo changes of composition through bacterial action from complex proteins to ammonia, nitrites and nitrates. Inorganic forms (i.e. nitrates) can be reconverted to organic compounds through photosynthesis. These changes from the organic to inorganic

form and then back to organic material are referred to as the nitrogen cycle.

Principal sources of nitrogen are municipal and industrial wastewater discharges, urban and agricultural land drainage, and precipitation; in many lakes, aquatic organisms can remove nitrogen directly from the atmosphere.

(a) Spatial Surface Distribution

Figure 5.2 illustrates the concentration of total nitrogen in the surface waters of Lake Simcoe for the years 1970 to 1973. Not unlike phosphorus the nitrogen levels can be described as being fairly low, with little horizontal variation throughout the lake basin. The offshore waters of Lake Simcoe averaged about 0.38 mg/l of total nitrogen.

While nitrogen levels were quite uniform throughout the lake, there were localized areas where concentrations were somewhat elevated. For example in Cook Bay near the mouth of the Holland River, nitrogen levels averaged about 1 mg/l. In Cook Bay, levels of nitrogen generally ranged from 0.40 to 0.60 mg/l, a moderate elevation over the open lake concentrations. The second local area of nitrogen enrichment was in Shingle Bay near the mouth of Ben's Ditch, where the mean nitrogen levels were 1 to 2 mg/l in 1971 and 1972. Thirdly, there appeared to be a slight nitrogen build-up in the west end of Kempenfelt Bay near the outfall from Barrie's sewage treatment plant. In addition to these three local areas, there was some evidence of slight increases in levels of nitrogen at some locations along the eastern and southern shorelines where rivers empty into the lake. However, since the concentrations at these locations were fairly close to background lake levels and much lower than the river concentrations, it would appear that the nitrogen from the rivers is either rapidly dispersed or contained in particulate matter which settles very quickly to the lake bottom near the river mouth.

(b) Organic and Inorganic Fractions

The ratio of inorganic to organic nitrogen was fairly consistent in a large majority of samples collected. About 95 percent of the nitrogen was consistently tied up in organic form and 5 percent inorganic (i.e., ammonia, nitrite and nitrate). A typical water sample from Lake Simcoe proper yielded the following results: 0.37 mg/l Kjeldahl N, 0.01 mg/l ammonia N, 0.01 mg/l nitrate N, and 0.002 mg/l nitrite N. The significant diversion from this typical ratio of nitrogen forms was evident at only one sampling station near Ben's Ditch (which contained the wastes from the Orillia STP). This station had a much higher percentage of inorganic nitrogen than the other stations throughout the lake. In fact, the inorganic fractions typically exceeded the organic nitrogen fractions, reflecting the loading from the Orillia sewage treatment plant which contained a high ratio of inorganic to organic nitrogen.

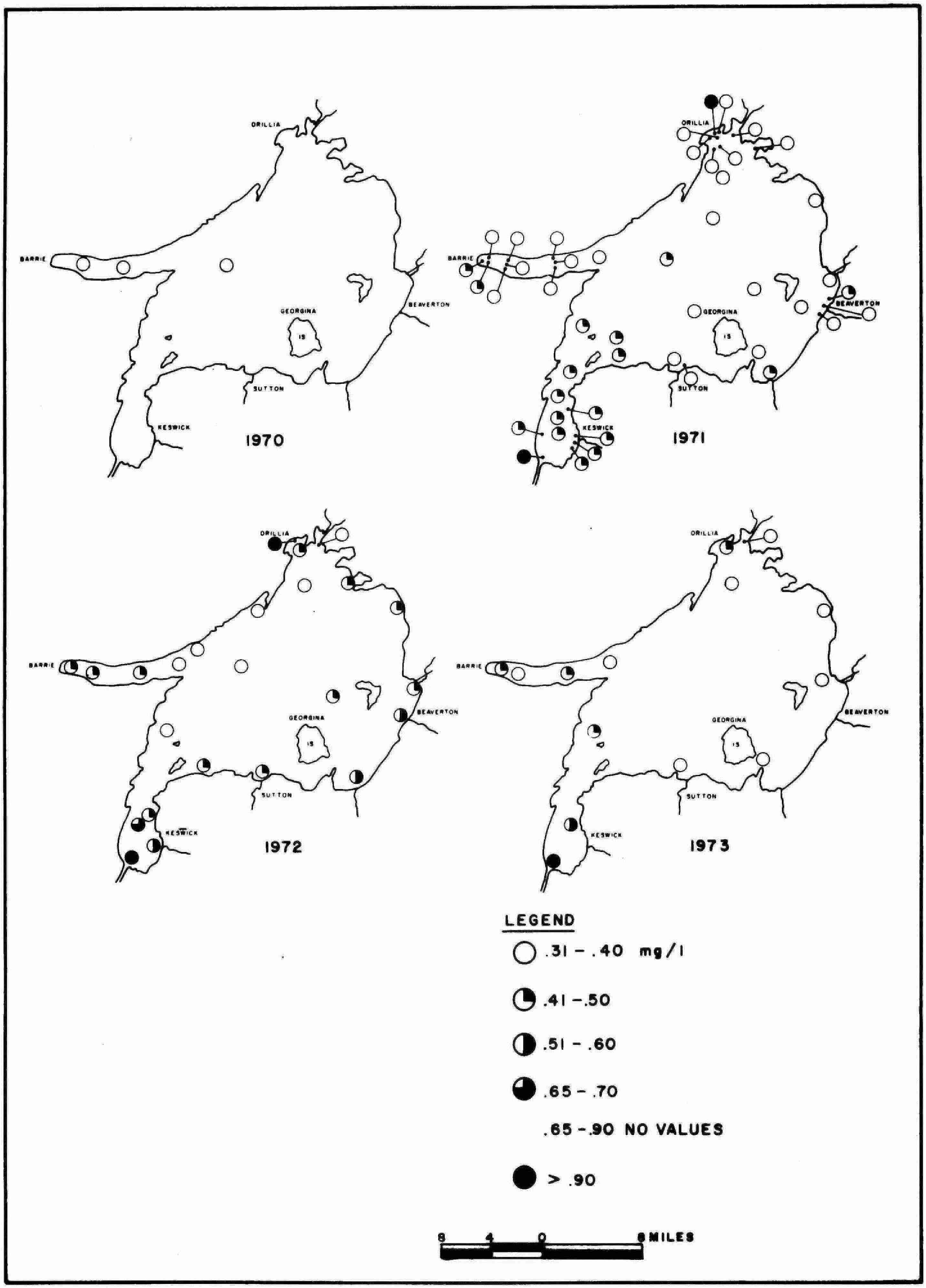

FIG. 5.2 TOTAL NITROGEN CONCENTRATIONS IN SURFACE WATERS

(c) Vertical Distribution

In general, it appears that there were only slight differences in the concentrations of total nitrogen through the vertical column, even during the summer stratification period. However, the nitrate fraction was typically more concentrated in the bottom waters than in the surface waters, probably reflecting the oxidation of organic nitrogen compounds in the hypolimnetic zones. The ammonia and nitrite fractions revealed minimal vertical differences. The following table illustrates the average differences between surface and bottom nitrogen levels.

Table 5.1 Average differences between surface and bottom nitrogen concentrations. (+/bottom higher, -/bottom lower.)

	Nitrogen as mg/l N			
Year	Free Ammonia	Kjeldahl	Nitrate	Nitrate
1970	-.011	-.039	+.011	+.015
1971	+.003	+.011	.000	+.022
1972	.000	+.011	+.001	+.019
1973	+.007	.000	+.002	+.052

5.1.3 Temperature

(a) Maximum Temperature

Lake Simcoe generally reached its maximum surface temperatures during early August, but in some cases, as early as the first week of July. The mean maximum temperatures during the three study years ranged between 21 and 22°C (70 and 72°F).

In sheltered and/or shallow areas of the lake, maximum temperatures were generally 2 to 3°C warmer than open lake readings.

Maximum recorded bottom temperatures occurred, as expected, in the shallow waters. Temperatures as high as 20° C were measured in 9 meters of water along the north and east shore of the lake and occurred at the same time as the surface maximum. However, in deep water the maximum (10 to 11°C) was reached later in the season just prior to the autumn breakdown of thermal stratification.

(b) Thermal Stratification

To achieve optimal representation of thermal data for interpretation, a series of cross-sections of the lake were constructed at two transects across the lake as illustrated in Figure 5.3. Typical examples representing the thermal regime

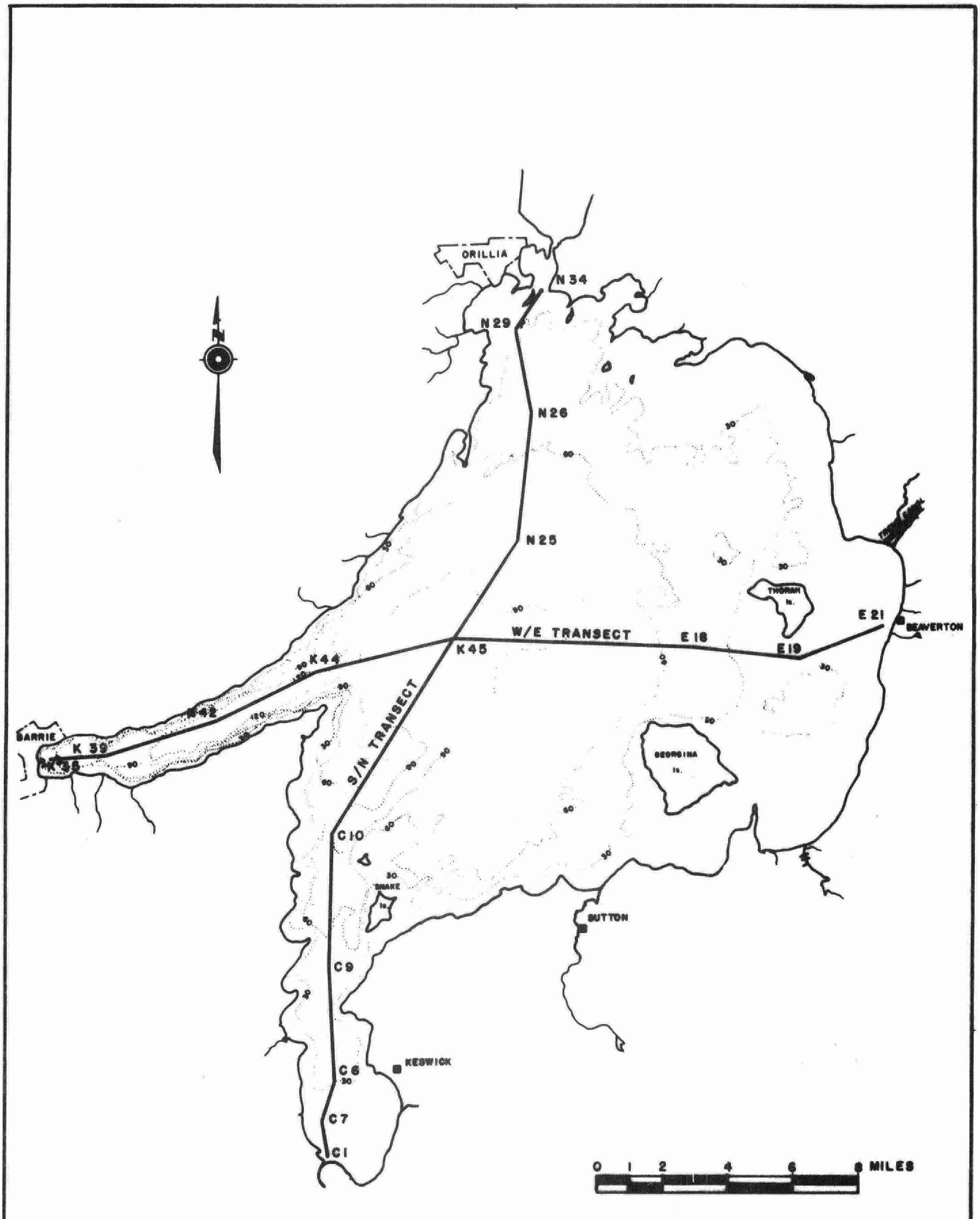

FIG. 5.3 TRANSECTS USED TO ILLUSTRATE THERMAL DATA

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for various periods of the year have been selected and are discussed below.

Following spring break-up the lake was still generally near the temperature of maximum density, 4°C, but quickly warmed in the shallower areas. The spring turnover was thus underway. Hubbard and Spain (1973) described this period in the annual cycle of a dimictic lake as being unstable, for as the surface water warms to 4°C it becomes more dense and sinks, causing vertical currents which provide for thorough mixing of the water column. Shortly after this time, the warming process became more pronounced starting from the shallowest and progressing into deeper water and at the same time a general warming occurred throughout the water column (Figure 5.4).

The warming continued through June, the thermal profile showing a more or less linear temperature decrease with depth from the surface, which is very well illustrated in Figure 5.5.

By mid-July, evidence of thermocline development was noted (Figure 5.6) but the thermal demarcation was rather vague, with temperature decreases of about 5 to 7°C through the depth range of 6 to 12 meters. In August, stratification became more pronounced, more compact and deepened to about 15 meters. The hypolimnetic waters warmed continuously throughout the summer indicating considerable heat transfer and therefore some degree of physical mixing with the epilimnion. Hypolimnetic waters reached 10 to 11° C by late August, although at this time, the surface waters had begun to cool slightly Figure 5.7).

Thermal stratification generally did not occur in those areas of the lake shallower than nine meters. Water temperatures in these areas were fairly uniform varying only 3 to 4°C from top to bottom.

At a few stations, a sharp thermocline was produced; however, the typical case was much less distinct showing more of a thermal transition through a depth change of 9 to 12 meters.

Progressing into September, the epilimnetic waters cooled, the thermocline deepened and the hypolimnetic waters continued to increase in temperature (Figure 5.8). Bottom waters as mentioned earlier generally reached their annual thermal maximum at this time.

The temperature differential between epilimnetic and hypolimnetic waters decreased until fall turnover and the water column became essentially isothermal at about 10°C by late October (Figure 5.9). Vertical homogeneity persisted throughout the winter until summer stratification began.

The annual process of thermal stratification and destratification followed this general pattern in each of the survey years. The timing of various stages varied somewhat with year to year weather differences, but the cycle of warming,

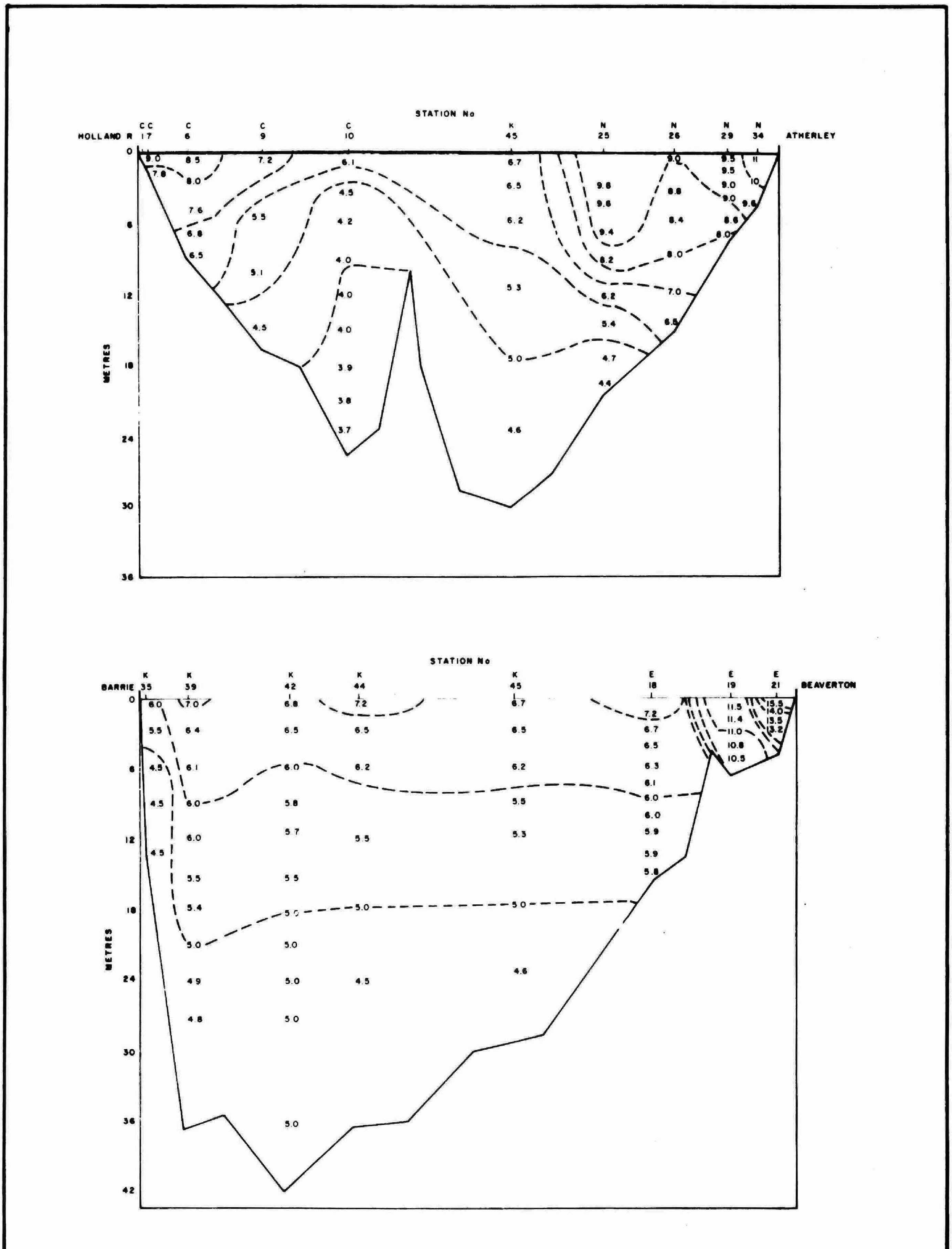

FIG. 5.4 TEMPERATURE PROFILES - MAY 17-19 (°C)

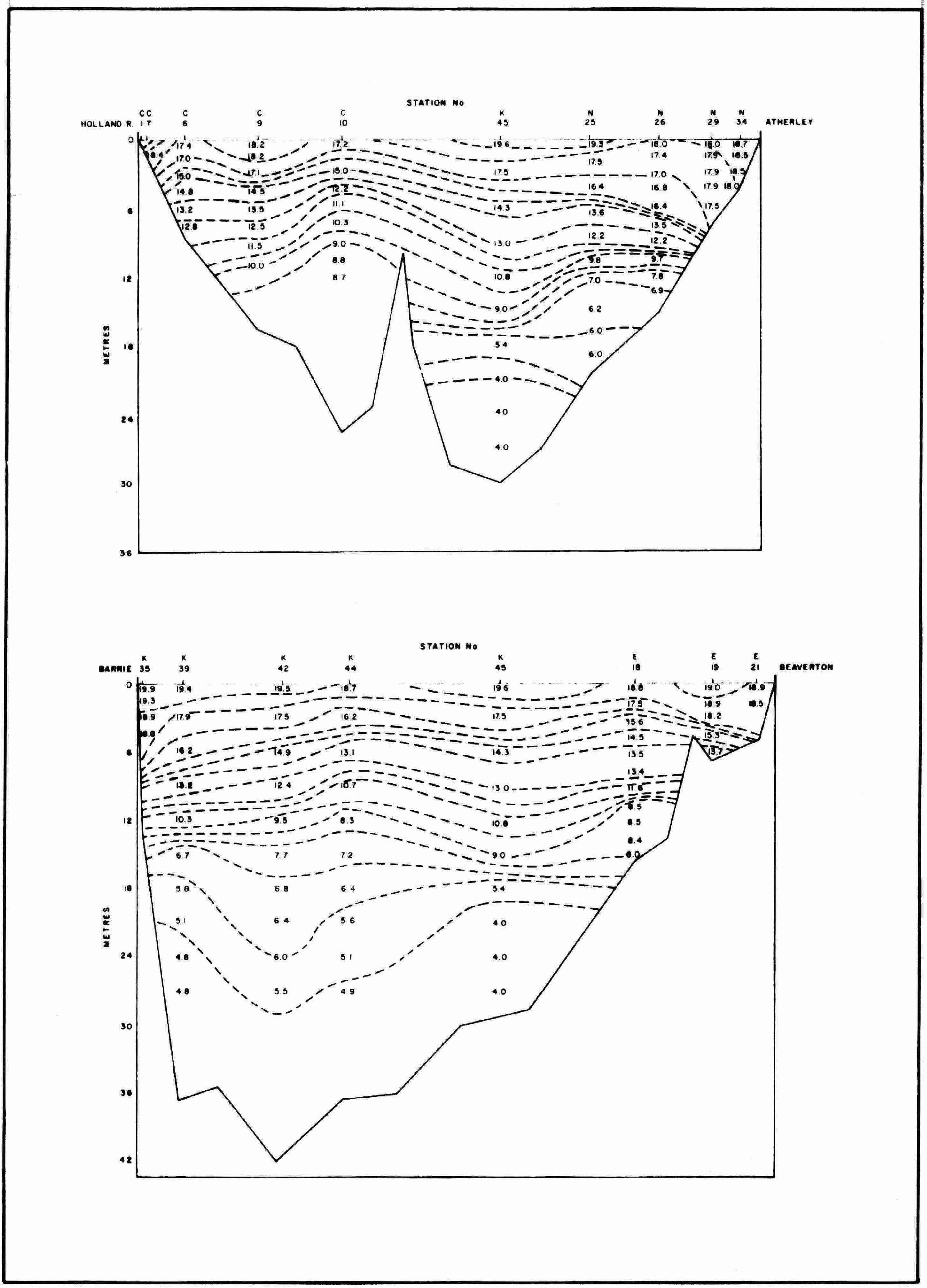

FIG. 5.5 TEMPERATURE PROFILES - JUNE 14-16 (°C)

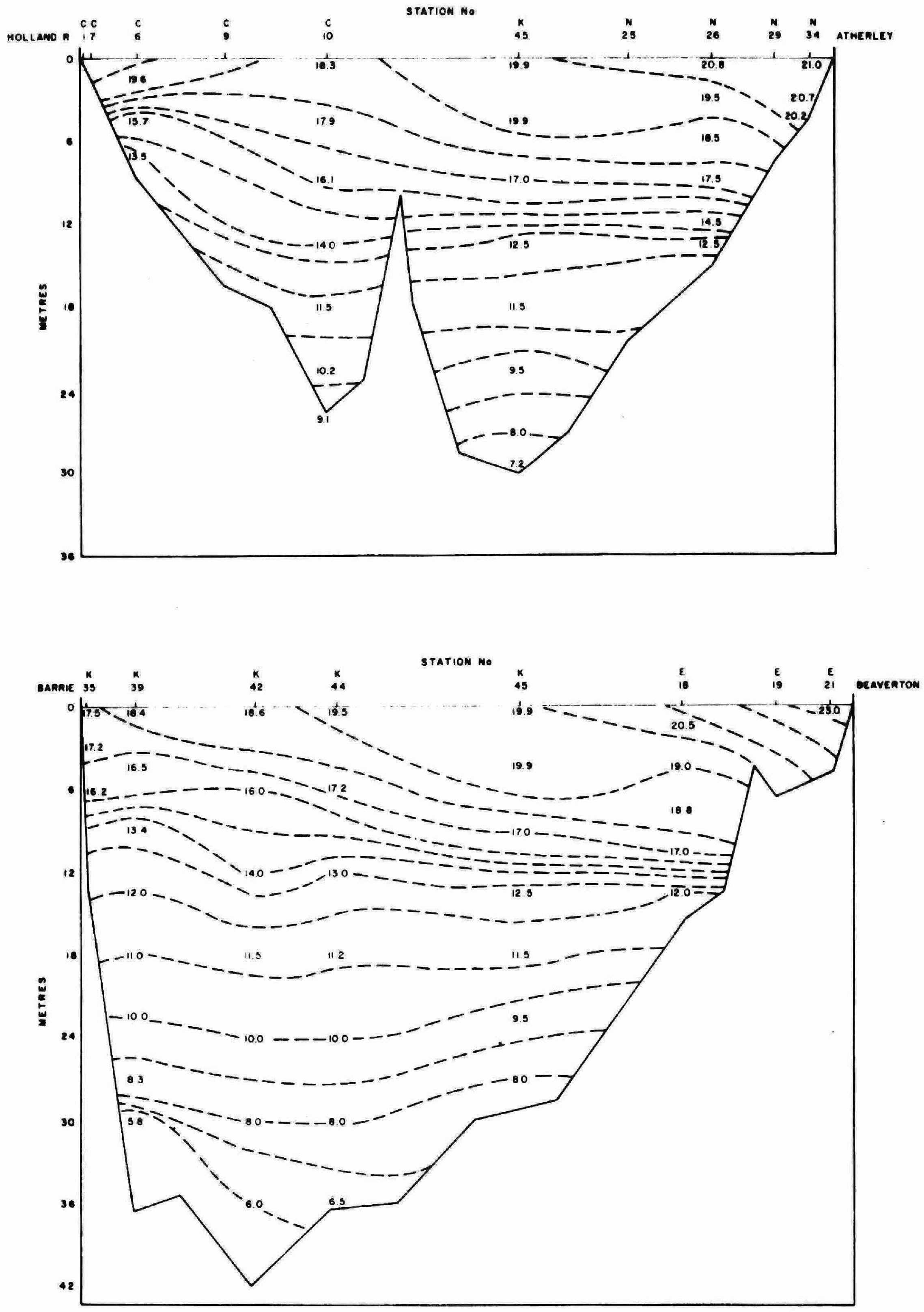

FIG. 5.6 TEMPERATURE PROFILES - JULY 12,13 (°C)

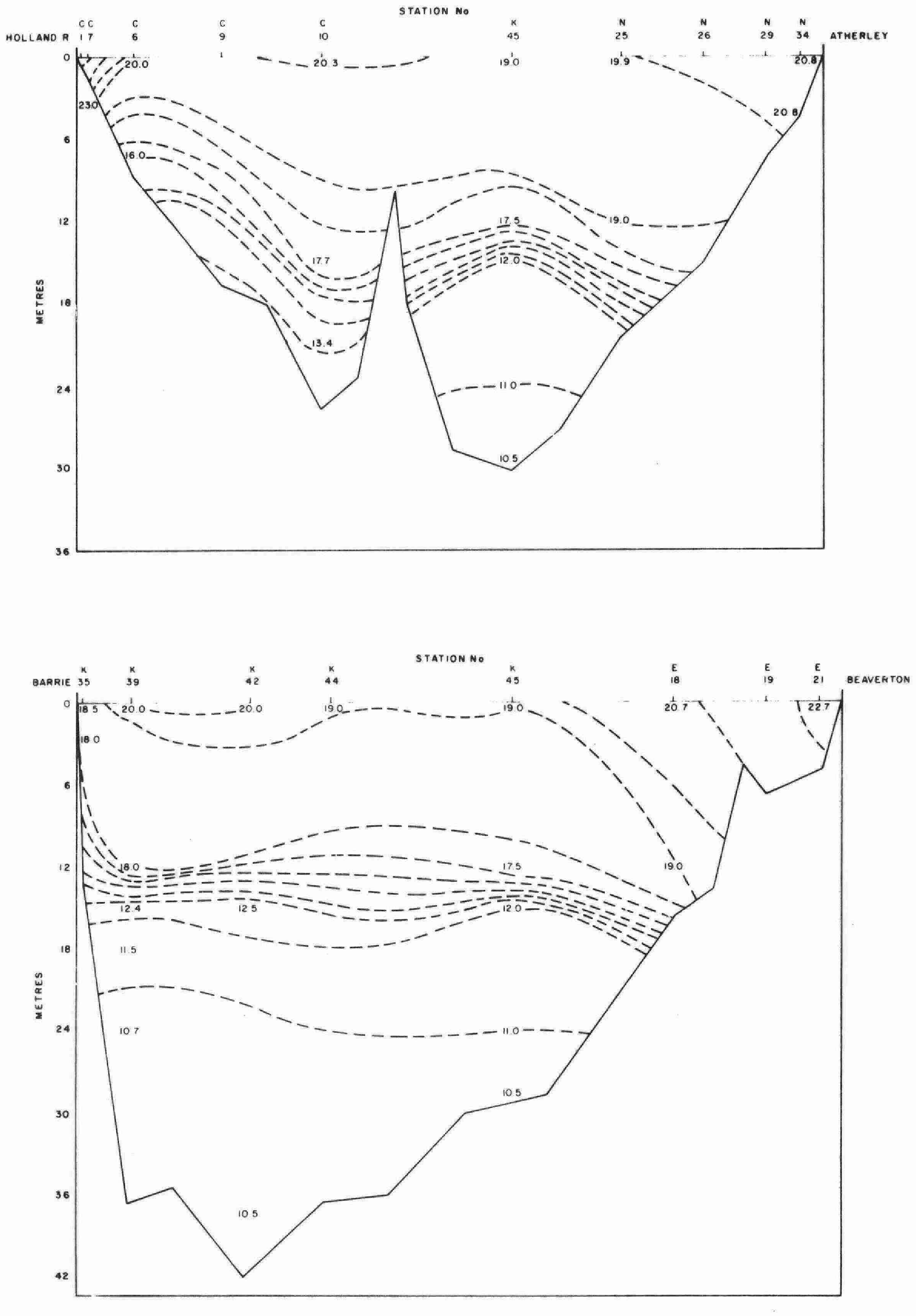

FIG. 5.7 TEMPERATURE PROFILES - AUGUST 22, 23 (°C)

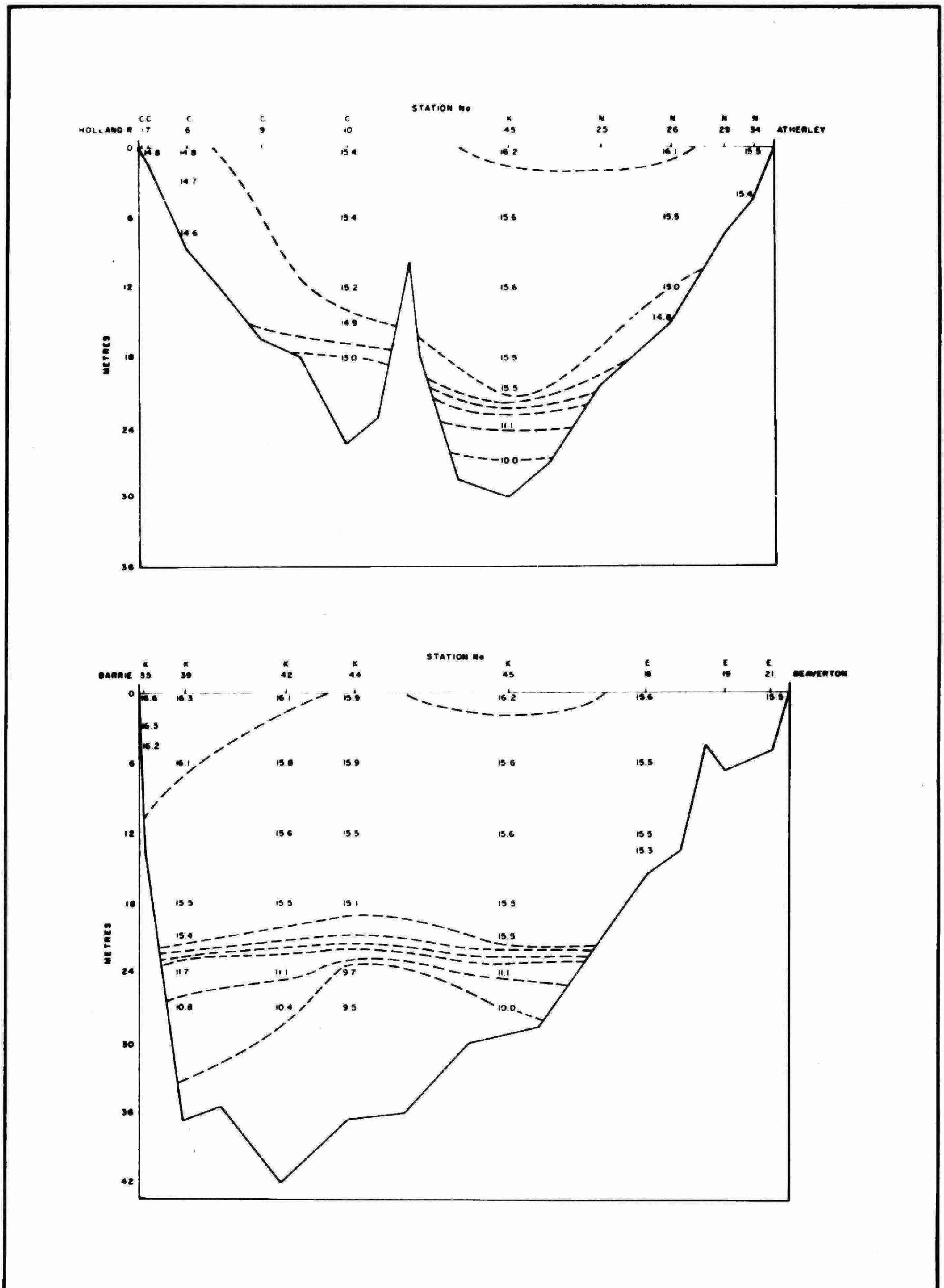

FIG. 5.8 TEMPERATURE PROFILES - OCTOBER 3-5 (°C)

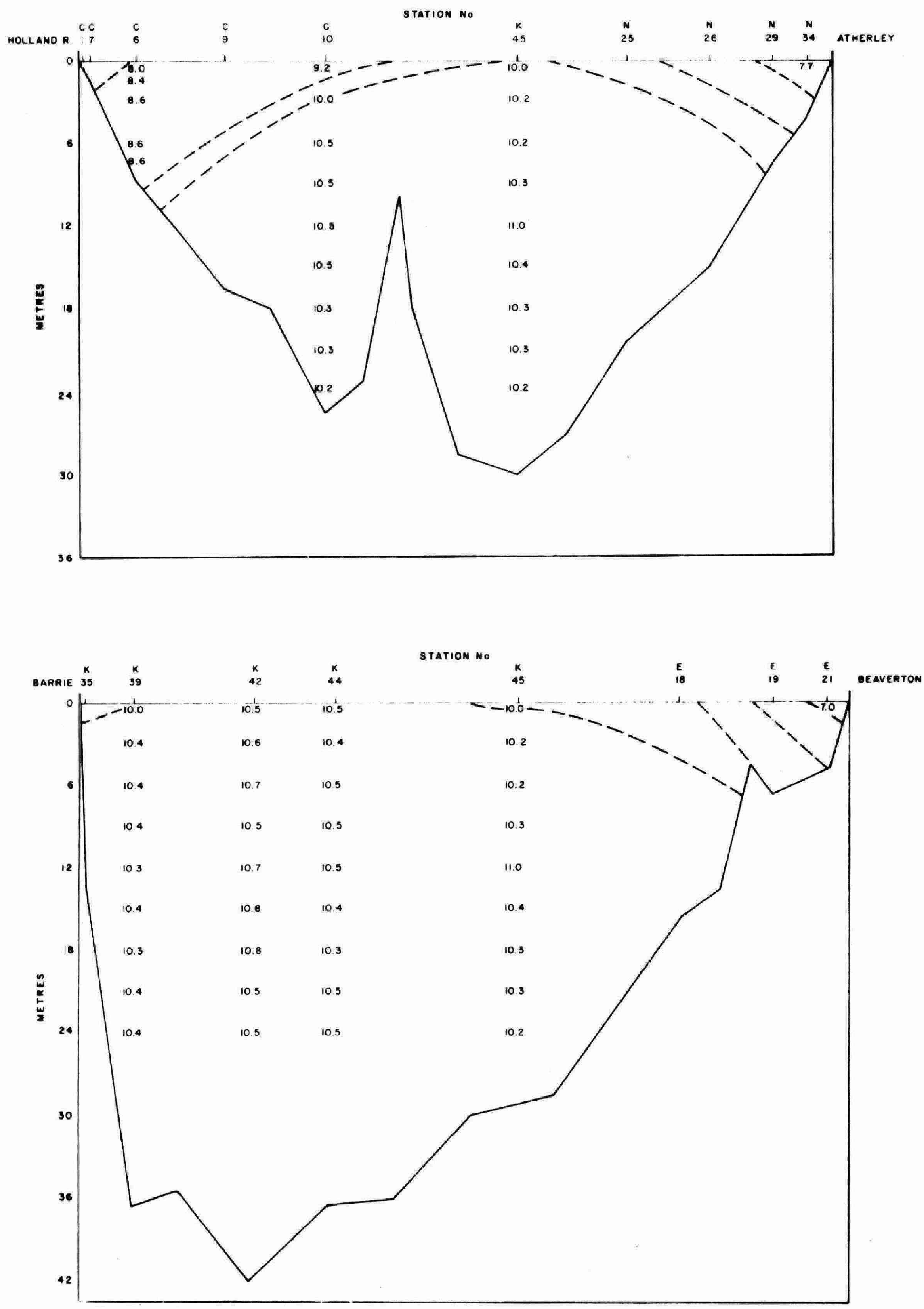

FIG. 5.9 TEMPERATURE PROFILES - OCTOBER 25 (°C)

thermocline formation, epilimnetic cooling with hypolimnetic warming and destratification was consistent throughout the study period.

5.1.4 Dissolved Oxygen

Dissolved oxygen in water is essential for sustaining a healthy and varied fish population and other aquatic life. The concentration of dissolved oxygen in fresh water at equilibrium is a function of temperature; the ability of water to hold oxygen decreases with increases in water temperature. Natural waters, however, are seldom exactly at equilibrium (i.e. 100 percent saturated) for temperatures are changing and physical, chemical, biochemical or biological activities are utilizing or liberating oxygen.

The principal sources of oxygen are the atmosphere and the photosynthetic process in green aquatic plants. Under conditions of excessive plant growth an over-abundance of oxygen can be produced and the dissolved oxygen level can exceed 100 percent saturation.

Losses of dissolved oxygen occur through normal respiration of aquatic animals and plants. With an over abundance of aquatic plants, night-time oxygen losses due to plant respiration can be serious and occasionally critical. Major losses of oxygen, however, are usually associated with the oxidation of unstable organic matter through chemical or bio-chemical actions. Major sources of organic material are municipal and industrial wastewater discharges, land runoff and decaying aquatic vegetation.

(a) Survey Findings

Discussions related to dissolved oxygen levels in Lake Simcoe must be separated into two zones, the epilimnion and the hypolimnion.

The surface water (the top 12-18 meters), referred to as the epilimnetic zone, has an abundant supply of oxygen throughout the entire surface area throughout the year. Levels during the four survey years were very stable and ranged from 80 to 110 percent saturation. Levels in the vicinity of the dense weed beds in Cook and Shingle Bays were consistent with the concentrations in the open water areas. The supply of oxygen in the surface waters of Lake Simcoe is excellent and should result in no water quality or use problems.

The deep water (hypolimnetic zone) underlying the epilimnetic zone did illustrate dissolved oxygen depletion during the period of vertical stratification from mid-summer through the early fall. Following spring lake turnover, usually in May, dissolved oxygen concentrations were uniform and near100 per cent saturation throughout the vertical column. As the thermocline was forming during the early summer dissolved oxygen levels in the hypolimnion began to decrease and continued to drop at a generally uniform rate through the

summer and early autumn reaching a minimum of 20 to 30 percent saturation (2 to 3 mg/l) prior to autumn turnover, which usually occurred in September or October. When turnover was completed and the stratification was broken, nearsaturated dissolved oxygen levels again were established throughout the vertical column and persisted during the period of ice cover. The hypolimnetic dissolved oxygen cycle described above followed a similar pattern during each of the field study years. Causes of oxygen depletion in the hypolimnion are discussed in Section 7.2.

In addition to the general dissolved oxygen work, a brief investigation was also made of the dissolved oxygen within the rocky spawning shoals. SCUBA divers collected water samples from Long Shoal in August, 1971 and the rocky shoal north of Georgina Island on March 3, 1973. By inserting a two inch needle of a 100 ml syringe into the gravel where lake trout and whitefish eggs would develop, water samples were obtained. Dissolved oxygen analyses in several of these samples, revealed oxygen levels near 100 percent saturation indicating excellent potential for egg development.

Silver (1963) pointed out the importance of dissolved oxygen concentrations being near saturation in the immediate vicinity of developing salmonoid eggs and the Ministry of the Environment recommends a level of at least 7 mg/l dissolved oxygen in spawning areas for cold water biota.

5.1.5 Water Clarity

Figure 5.10 illustrates the secchi disc means for 1970, 1971 and 1972. While there were considerable differences in water clarity in the various parts of Lake Simcoe an average secchi disc value for the offshore region of Lake Simcoe proper appeared to be slightly greater than 4 meters. It should be noted that Secchi, disc measurements were generally greater than 4 meters during the spring and late fall and less than 4 meters during the late summer. The decreased clarity during the summer months is likely the result of increased phytoplankton populations. In general, excluding the "brown water systems", lakes having a secchi disc value of 3 meters or less are eutrophic in nature, while those exceeding 5 meters are oligotrophic (Michalski, personal communication). Therefore, based on secchi disc readings, Lake Simcoe would lie between these two trophic levels.

Figure 5.10 also illustrates that while the offshore waters of the lake were quite clear some of the inshore areas were much more turbid. The areas with the lowest secchi disc readings were the southern end of Cook Bay, and various locations along the eastern shoreline. The reduction of water clarity in the south end of Cook Bay was no doubt a result of the turbid waters of the Holland River entering the bay, and the wave-induced resuspension of lake-bed sediments in shallow waters.

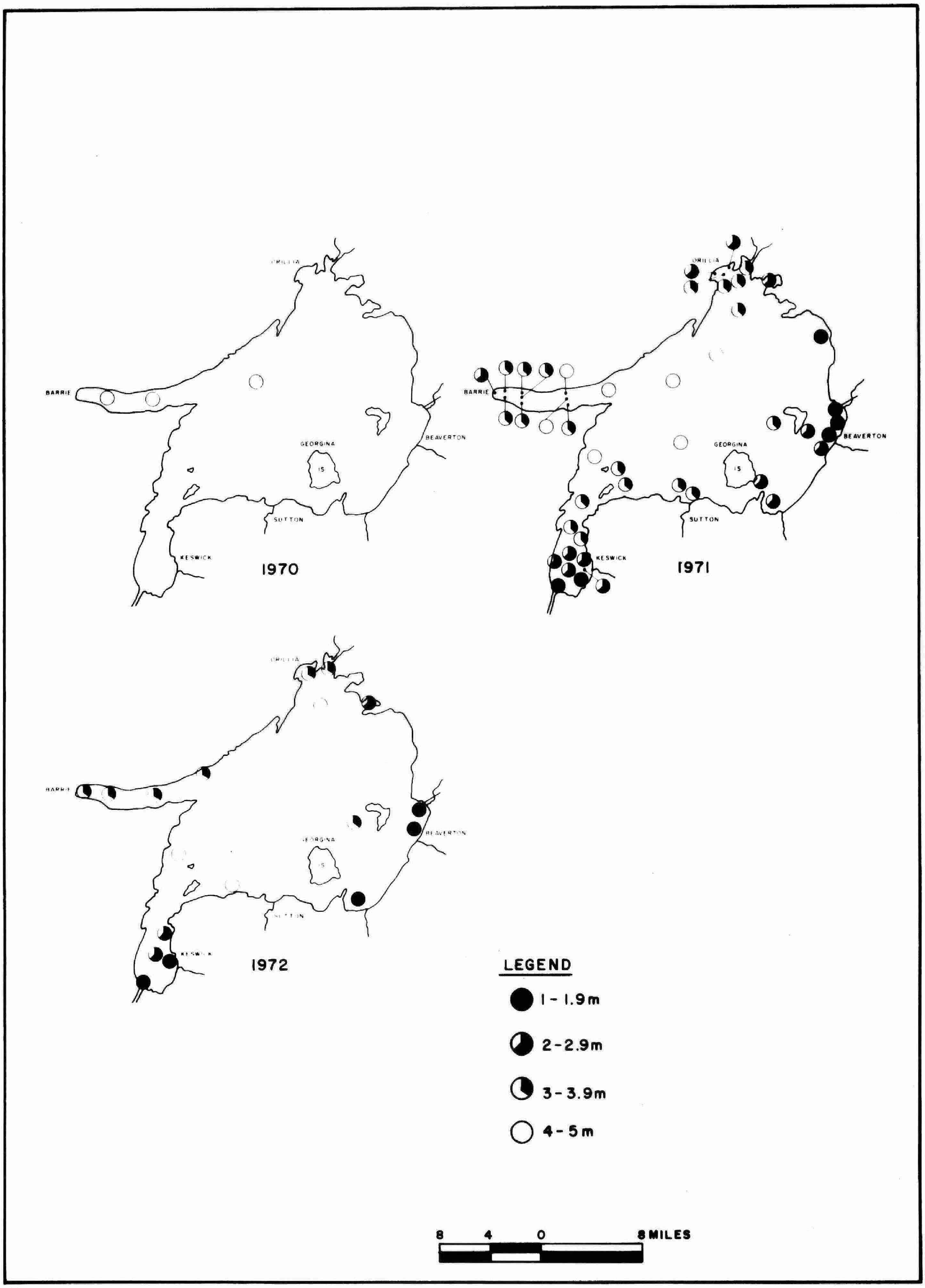

FIG. 5.10 SECCHI DISC MEANS

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Data on average turbidity values reveals that the surface waters of the lake were quite uniform with an overall lake mean of 3 JTU. A definite increase in turbidity over the general lake values was apparent at only one sampling location, at the mouth of the Holland River where the average value was 10 JTU for both 1971 and 1972.

An examination of turbidity data for the vertical column suggests that in deep water (greater than 18 meters) surface turbidity was generally the same as bottom turbidity, however, in shallower water (between 9 and 18 meters) bottom turbidity was usually 0.2-0.5 units higher than surface turbidity. A probable explanation for this difference is that in the shallow water areas of the lake, currents and wave action, boating, etc., suspend sediments to create increased bottom turbidity.

5.1.6 Hardness

Hardness in water is caused by dissolved divalent metal ions, calcium and magnesium being the most common. Lake Simcoe waters can be described as moderately hard, averaging slightly greater than 140 mg/l as $CaCO_3$. This level would have no significant effect on normal lake uses. Hardness was very uniform throughout the horizontal and vertical planes of Lake Simcoe. The only notiable exception was the area directly adjacent to the mouth of the Holland River where the average hardness level was 155 mg/l.

5.1.7 Alkalinity

Alkalinity of natural waters is caused primarily by the presence of carbonates, bicarbonates and other salts of weak acids. Alkalinity throughout Lake Simcoe was quite uniform and averaged about 120 mg/l as $CaCO_3$. This level has no significant affect on normal water uses.

5.1.8 Conductivity

The conductivity test provides a simple and convenient method of measuring indirectly the presence of mineral salts. In itself, conductivity has no effect on normal water uses, but used as a gauge to monitor changes in water quality, the conductivity test may indicate areas where water quality problems exist.

The conductivity of Lake Simcoe waters was low, approximately 300 μmhos/cm^3, with little horizontal variation and only a small increase in levels in the bottom waters. Conductivity levels were considerably elevated near the mouth of the Holland River and slightly elevated in Shingle Bay near Ben's Ditch.

5.1.9 Colour

Colour in water may be of natural mineral or vegetable origin caused by metallic substances, such as iron and manganese compounds, humus material, peat, tannins, algae, weeds and protozoa. Industrial wastes may also impart colour to water. Although not considered harmful from a health standpoint, colour may be undesirable from aesthetic considerations.

The waters of Lake Simcoe contained low levels of colour with most of the samples collected containing colour values of less than 5 Hazen units.

5.1.10 Iron

Iron in water may result in the growth of iron bacteria causing unpalatable taste, discolouration of clothes and plumbing fixtures, and scales in water mains.

Levels of total iron in Lake Simcoe were very low with little horizontal or vertical variations. Most samples contained concentrations of iron less than 0.05 mg/l; however, the average level at the mouth of the Holland River was 0.2 mg/l in 1971.

5.1.11 Chlorides

Chlorides are found in practically all natural waters. They may be of natural mineral origin, but in general the largest contributions can be traced to domestic sewage discharges, municipal storm drainage and industrial wastes.

High concentrations of chlorides may make water unfit for municipal supplies (greater than 250 mg/l), industrial supplies (greater than 100 mg/l for brewing purposes) and irrigation (tobacco irrigation, greater than 70 mg/l).

Chloride levels in Lake Simcoe were very low and uniform with an average level of 12 mg/l for the lake.

5.1.12 pH

pH is an index of the acidity or alkalinity of a solution. The pH range extends from 0, strongly acidic, to 14, very alkaline, with a middle level of pH 7 corresponding to neutrality at 25°C.

The natural pH of a lake is largely controlled by the geology of the lake bed and surrounding land; however, biological processes can control pH to some extent with primary productivity increasing pH and organic decomposition decreasing pH as a result of biological processes changing the carbonate-bicarbonate equilibrium.

Normally, pH levels in lakes in Southern Ontario tend to be slightly alkaline around 8 pH units. Levels in Lake Simcoe averaged 8.3 pH units with little areal variation. In the deeper parts of the lake (greater than 20 meters) pH levels

were about 0.5 units lower than in the surface waters, probably the result of the effect of benthic decomposition of organic materials.

5.1.13 Chlorophyll

Chlorophyll a is the green pigment in plants which is responsible for the photosynthetic process. The concentration of this pigment in water has been used to estimate the standing crop of phytoplankton and for the rate of phytoplankton growth.

The 1971 concentrations of chlorophyll a throughout most of Lake Simcoe were low and did not show any significant seasonal pattern throughout the sampling period (May to November). The large majority of samples collected contained chlorophyll a values ranging from below 1 μg/l to 3 μg/l. Average values for all but eight of the sampling stations were below 3 μg/l. One of these eight stations was located in Shingle Bay and had an average value of 3.2 μg/l. The other seven locations were all in the southern part of Cook Bay; the average concentrations are illustrated in Figure 5.11.

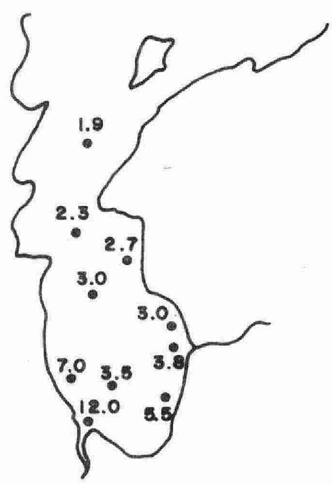

FIG. 5.11 CHLOROPHYLL a CONCENTRATIONS IN COOK BAY

In order to place these chlorophyll values into proper perspective, it has been suggested (Michalski, Personal Communications that concentrations between 0 and 3 μg/l are low and indicate low to moderate algal densities. Concentrations between 3 and 6 μg/l, although moderately high, may be considered acceptable for most water-oriented recreational pursuits. Levels greater than 6 μg/l reflect high algal stocks.

D. VEAL - INVESTIGATOR
• DATA USEFUL STUDIES AT CENTRAL REGION

5.1.14 Phytoplankton

(a) Populations

The populations of phytoplankton (microscopic, free floating algae) appeared to be similar throughout the various parts of Lake Simcoe. The 1971 sampling showed a fairly close similarity between the nine sampling locations in terms of both phytoplankton density (number of cells per millilitre) and generic composition. Figure 5.12 illustrates the algal data.

It is of interest to note that of the four main groups of algae (diatoms, greens, blue-greens, flagellates), bluegreens and flagellates dominated throughout most of the sampling period. Samples collected in the early part of the summer (May and June), however, tended to have a dominance of flagellates and diatoms. Green algae was found only in low densities throughout the sampling period.

TABLE 5.2: Number of samples in which the following genera were either dominant or sub-dominant (see Fig. 4.1 for sample station locations)

	C6	C9	C19	N26	N31	K35	K39	K42	K45
Blue-greens									
Aphanothece	3	4	3	3	3	3	4	3	2
Anabaena	1		3	2	2		1	1	
Chroococcus		2				1	1		
Microcystis				1				1	
Gomphosphaeria			1	1				1	
Oscillatoria	1				1	1			
Lyngbya					2				
Aphanizomenon	1								
Flagellates									
Rhodomonas	2	2	2	2	4	2	4	5	1
Chlamydomonas	4	4	1	3	3	4	4	5	3
unid. Chrysophyte	1	1				2	2	1	1
Dinobryon			2	1	1	1			1
Synura			1						
Diatoms									
Stephanodiscus	1				3	1	1		1
Fragilaria	2	3	3	1	1		1	1	1
Tabellaria		2							
Green									
Crucigenia						1			
No of Samples Collected	8	9	8	7	10	8	9	9	5

Figure 5.12 also illustrates the two dominant genera, in terms of cell members, found in each sample. Due largely to the

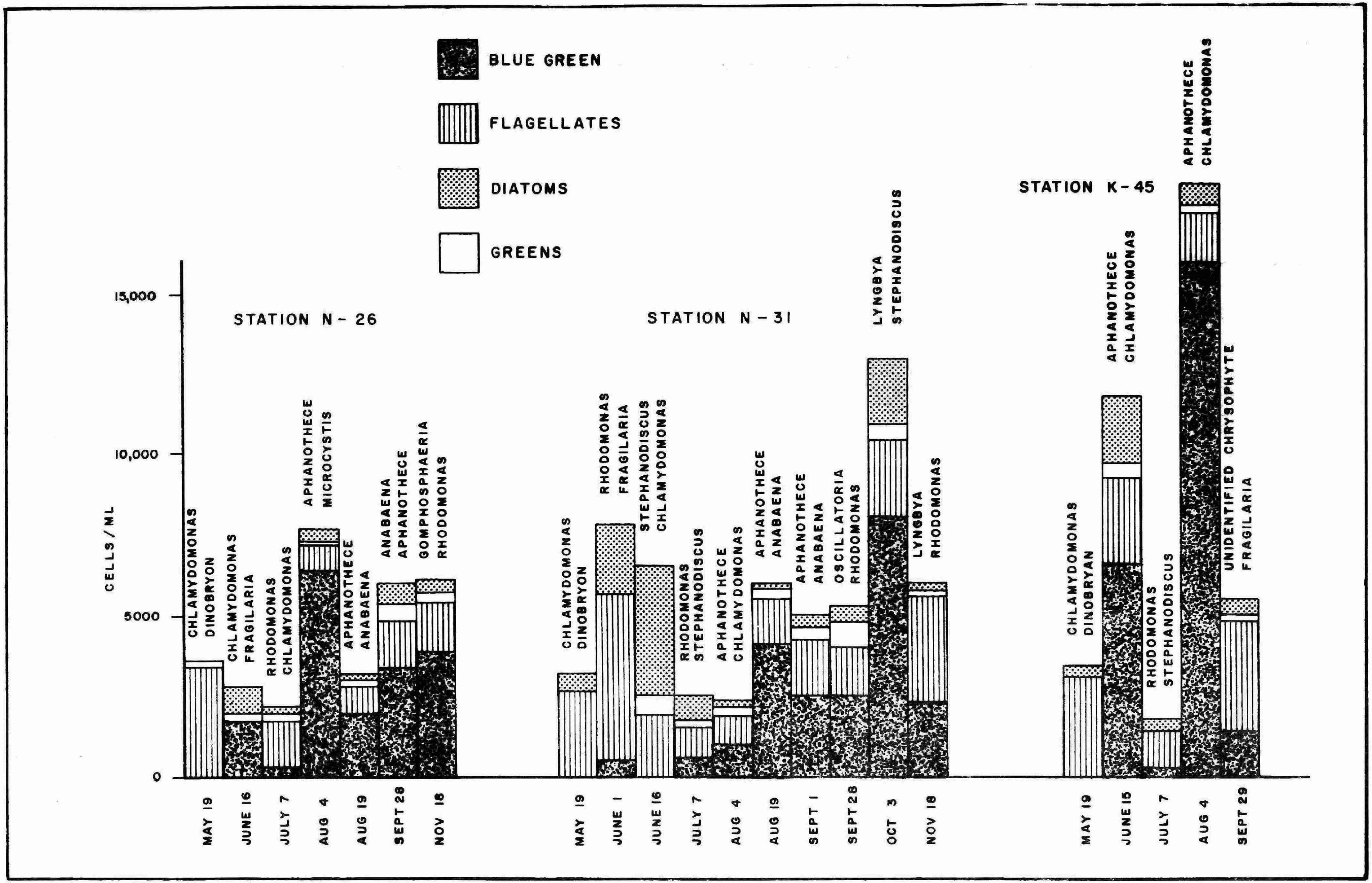

FIG. 5.12 PHYTOPLANKTON LEVELS AT NINE LOCATIONS IN THE LAKE (SEE FIG. 4.1 FOR STATION LOCATION)

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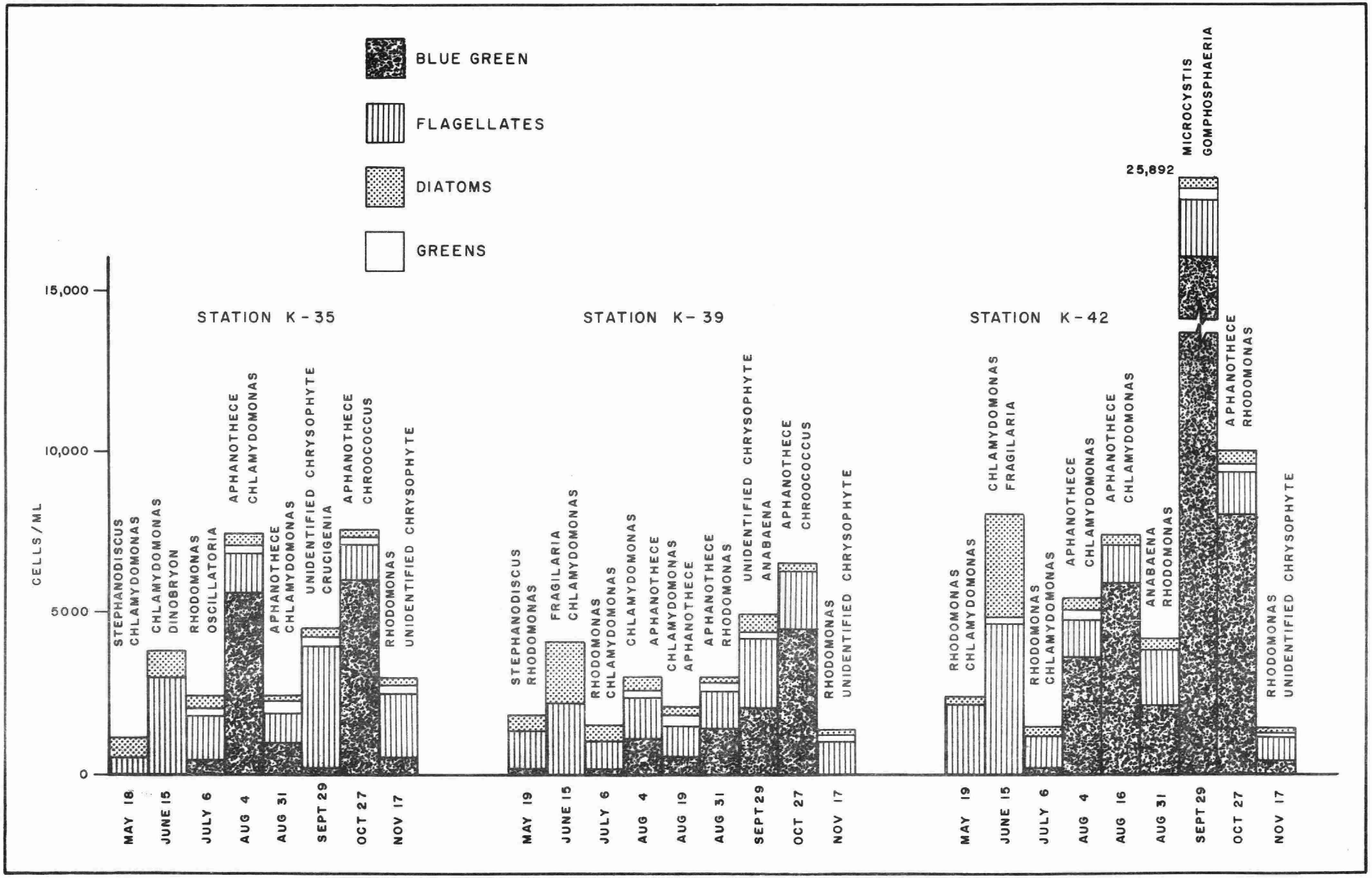

FIG. 5.12 CONT'D

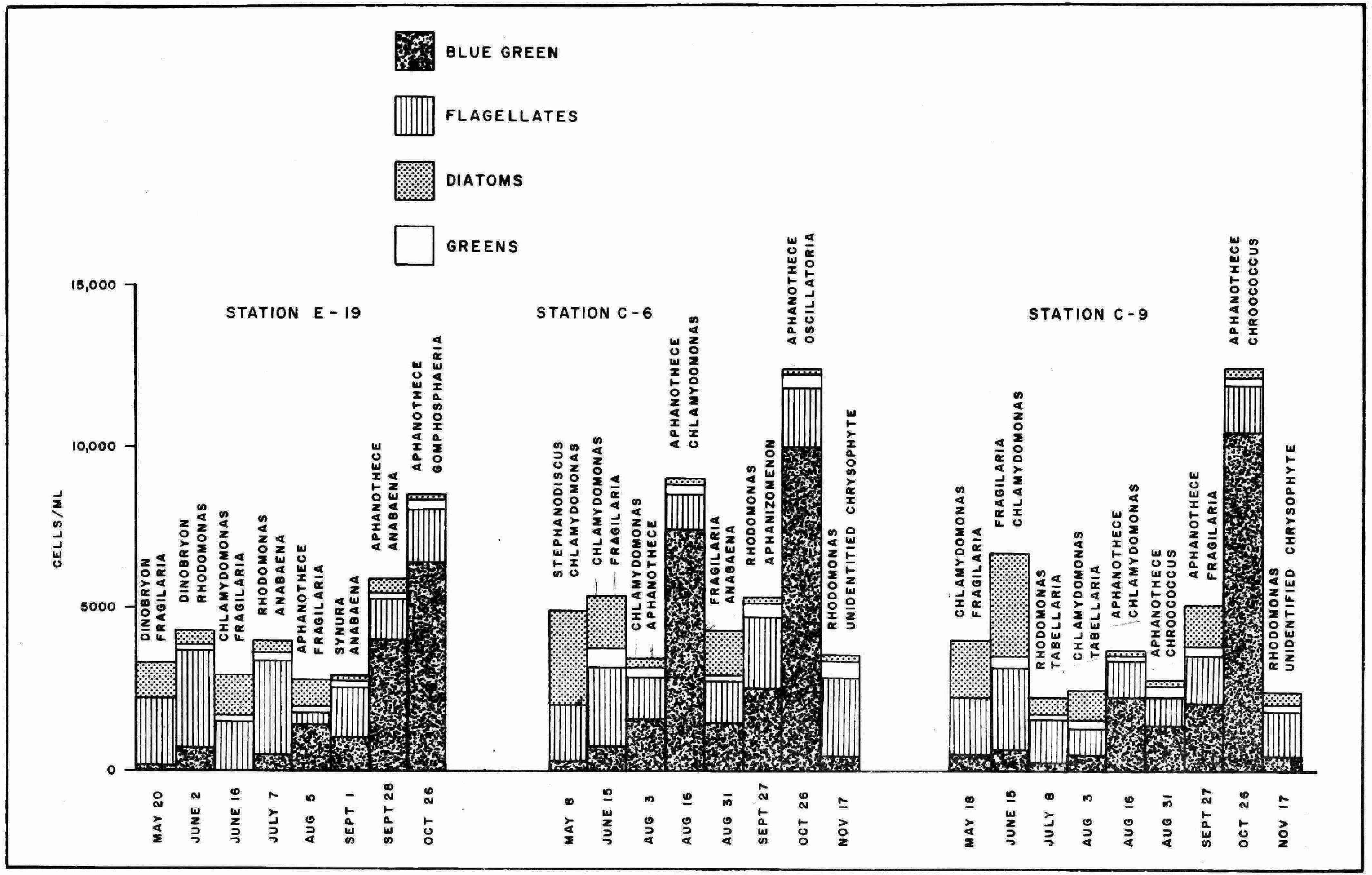

FIG. 5.12 CONT'D

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infrequency of sampling, the data do not illustrate a clear-cut pattern with respect to seasonal changes in generic dominance. There was, however, a similarity of dominants throughout the lake with Chlanydononas, Aphanothece and Rhodomonas being the three genera which most frequently dominated the algal population. Table 5.2 illustrates the genera which were dominant or sub-dominant in at least one of the samples collected. Of the seventeen genera listed, eight are blue-greens, five are flagellates, three are diatoms and one is a green.

(b) Phytoplankton Productivity

Phytoplankton productivity is a measurement of the rate at which the microscopic free-floating algae convert inorganic nutrients into living cell material, resulting in phytoplankton growth.

Average productivity values on an areal basis varied from 56 milligrams of carbon per square meter per day in Shingle Bay to 127 mgC/m^2/day in the middle of Cook Bay. The overall mean for the five sampling locations was 91 mgC/m^2/day.

(c) Phytoplankton Scums

During the past four summers, periodic phytoplankton scums have been noted on Lake Simcoe primarily during the late summer-early autumn periods. The first algal scum ever recorded for Lake Simcoe proper by the Ministry of the Environment occurred in October of 1971. During late September, visible amounts of phytoplankton, assumed to be the blue-green alga Anabaena, were observed in the waters of Kempenfelt Bay, although no scum was evident. During the first part of October, surface accumulations were observed in various enclosed harbour areas in Kempenfelt Bay; typically these scums would materialize at night when the water was calm and the algae was then dispersed with the daytime winds. By October 20, an algal scum had developed over most of Kempenfelt Bay and most of the lake surface was covered with a phytoplankton layer. Samples of the material collected from the Barrie area of Kempenfelt Bay were identified as Anabaena and it is assumed that this genus was responsible for the lake-wide scum. October 20, 1971 was a very calm day and there was no doubt that the calm water allowed the light Anabaena cells to float to the surface and accumulate. The scum prevailed for several days until it was dispersed by wind and wave action.

In 1972, a lake-wide scum again developed, this time in early July. A sample collected from the Georgina Island area on July 5 was identified as Anabaena and it was again assumed that this genus was responsible for the lake-wide scum. This surface accumulation in July, like the 1971 scum, materialized in a period of calm, sunny weather.

The third scum, which was relatively minor compared to the first two, was recorded during the first few days of October

1972. A sample of the material again revealed Anabaena, although other genera of blue-greens (Apthanizomenon, Lyngbya, Coelosphaerium) were also present in the sample.

Scums were reported in early October 1973 and mid-June 1974. While the responsible alga was not identified, the lake-wide accumulations were similar to previous scums.

5.1.15 Aquatic Weeds[1]

Lake Simcoe, due to its extensive exposed shoreline and sand or rock bottom was found to support a very small crop of aquatic weeds (Figure 5.13). Substantial aquatic weed growths were limited to the shallow, sheltered bays such as Cook, Shingle, McPhee, Barnstable, and Carthew bays.

The accumulation of mud sediments in Carthew, McPhee and Barnstable bays has provided beds for fairly dense weed growths dominated by Chara, wild celery, Canada water weed, and milfoil. However, macrophytic production in these bays was not of significant magnitude to present problems of shoreline accumulations of dead weeds during late summer and fall.

In Shingle Bay, aquatic weed production reached nuisance levels and shoreline accumulations were aesthetically unattractive and often interfered with normal recreational uses. Weed densities varied considerably throughout the bay due largely to the variety of bottom sediments, but in several areas, 80 to 100 percent of the bottom was covered with macrophytes. Common plant types in Shingle Bay included slender pondweed, Chara, coontail, Canada water weed and sago pondweed.

Certainly the greatest abundance of aquatic weeds in Lake Simcoe was found in Cook Bay. The southern end of Cook Bay supported very dense weed growth while macrophytic production generally decreased towards the deeper northerly sections of the bay. Cottagers at the south end of the bay have been troubled annually with shoreline accumulations of aquatic weeds during the later summer and fall periods. Massive weed accumulations appear unsightly and have periodically created obnoxious odours on decomposition. Common plant types in Cook Bay included milfoil, flat-stemmed pondweed, Chara and wild celery with Chara being the most abundant plant type.

5.1.16 Attached Algae[2]

During July and August 1971, the shoreline of Lake Simcoe, including the major bays and two shoals considered to be potential spawning areas for whitefish and/or lake trout, were

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[1]*A more detailed documentation of weed growths is contained in an OWRC report entitled "Aquatic Weed Growths in Lake Simcoe (1971)".*

[2]*A detailed account of the attached algae growth is contained in a 1971 OWRC report entitled "Aquatic Weed Growths in Lake Simcoe".*

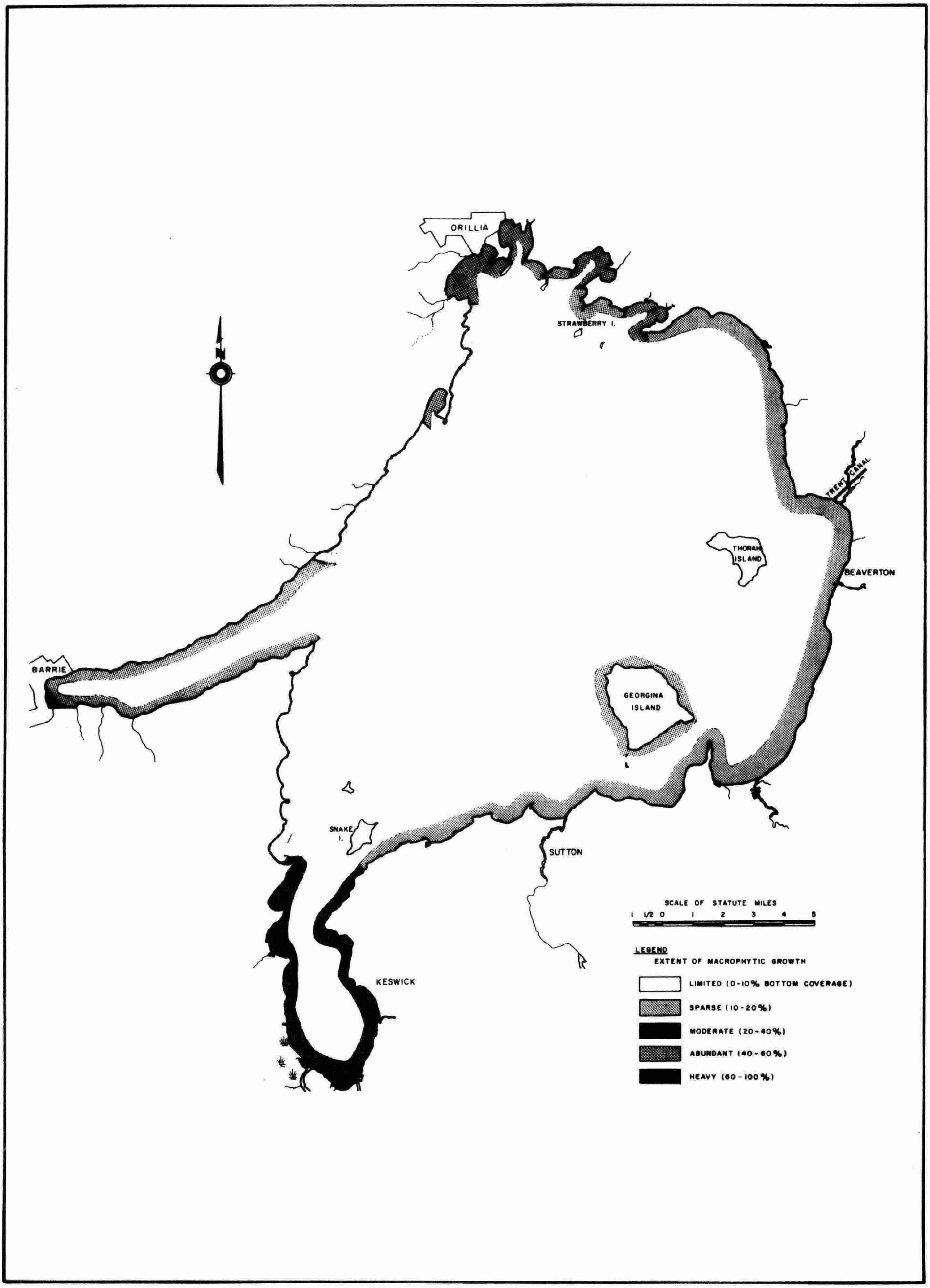

FIG. 5.13 AQUATIC WEED GROWTHS

examined for attached algae (periphyton). Of the 145 shoreline areas examined, only 52 were found to have visually-apparent amounts of periphytic growth. It appears that while the production of the periphytic alga Cladophora (often associated with nutrient enrichment) was significant at or just below the waterline in parts of Lake Simcoe, periphyton constituted a minor portion of the overall plant production.

At all locations, small bits of algae (2-3 cm in length) were normally found attached to a few rocks. At many of the stations where aquatic weeds were prevalent, periphyton was found attached to the macrophytes, particularly in Shingle Bay, where periphytic growths 10 to 15 cm in diameter were observed.

The 52 samples of attached algae that were collected revealed that Cladophora was by far the most common and abundant algal type. There appeared to be three species of Cladophora - Crispata, Oligoclona, and Glomerata. Many of the other plant types, particularly diatoms, were merely attached to the Cladophora filaments. The following list outlines the algal types in decreasing order of occurrence.

Cladophora (glomerata, crispata, oligoclona)
Odeogonium
Gloeotrichia
Spirogyra
Zygnema
Bulbochaete
Cymbella
Ulothrix
Rhizoclonium hieroglyphicum
Lyngbyia
Mougeotia
Cyclotella
Gomphonema
Cocconeis
Porifera (fresh water sponge)

Figure 5.14 illustrates the dominant plant types at various locations throughout the lake. Of interest, is the dominance of Zygnema in the southwest corner of Kempenfelt Bay, and the dominance of Oedogonium or Rhizoclonium at five locations in Shingle Bay. It has been suggested that these three algae may also be indicator organisms of nutrient enrichment.

There was, however, little evidence of periphytic growth on rocky spawning shoals. These areas should provide suitable spawning beds for cold water gamefish (i.e. lake trout and whitefish).

5.1.17 Bottom Fauna

Samples for bottom fauna examination were collected at 47 locations in Lake Simcoe during 1971.

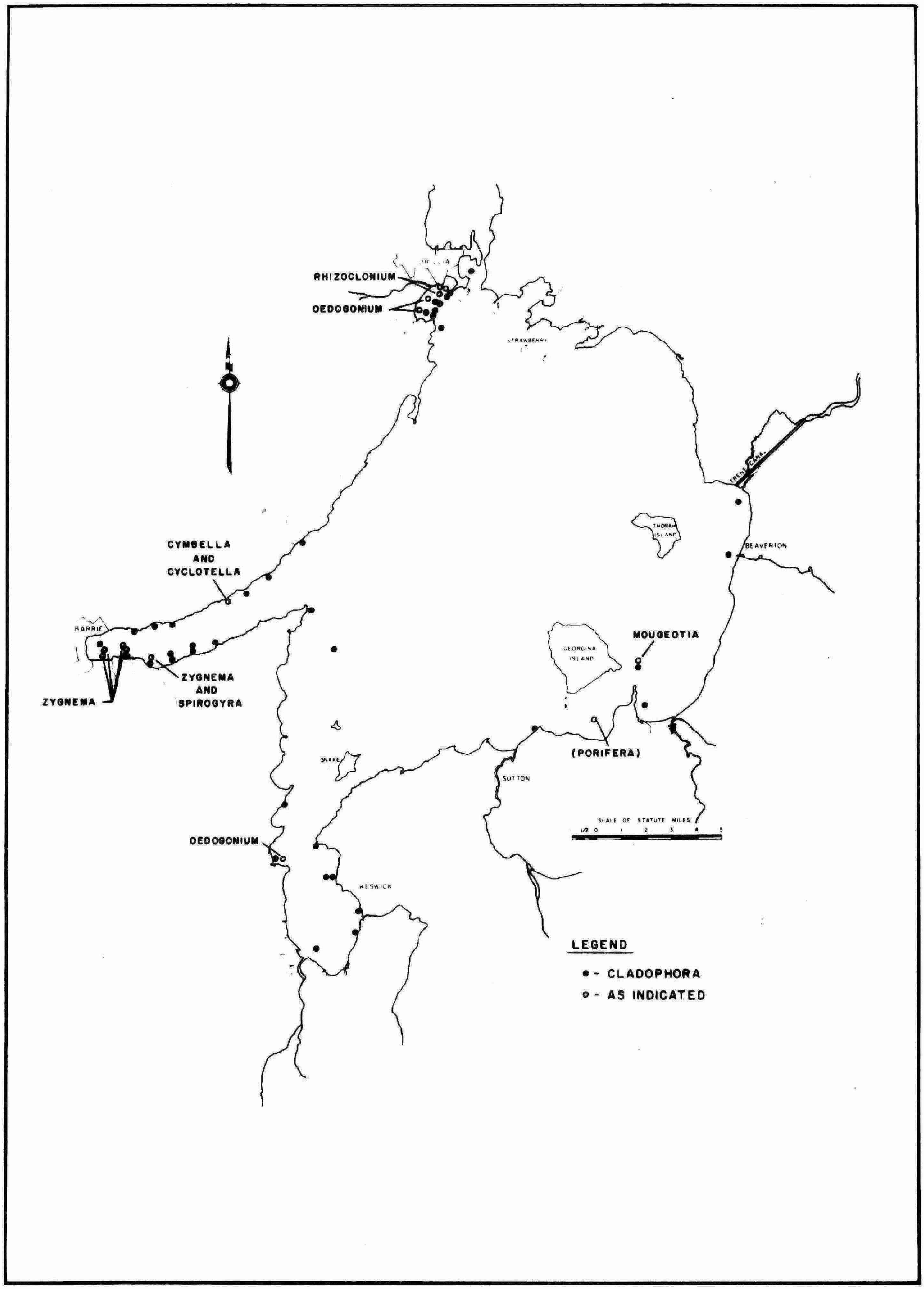

FIG. 5.14 DOMINANT ALGAL TYPES

(a) Density

The density of bottom invertebrates was fairly high throughout the Lake Simcoe basin with little apparent variation from area to area or from the shallow water areas to the deep water areas. The average density of organisms was approximately 3000 per m^2 (280/ft^2), ranging from 560 to 8,650 organisms per m^2 (52 to 800 organisms per ft^2).

(b) General Community Structure

Lake Simcoe was found to support a wide variety of benthic invertebrates with a good balance between the major groups of taxa (Figure 5.15).

The shallow water zones, 0 to 17 m, (0 to 60 feet) on the south, east and north sides of the lake basin contained a particularly diverse community with only minor structural differences from one area to another. Predominant groups in this shallow water area included midges (chironomids), worms (tubificids), amphipods, fingernail clams, snails, mayflies and caddisflies. In Cook Bay, the community balance was somewhat disrupted as inciated by (a) the abundance of midges, (b) the scarcity of mayflies and caddisflies and (c) the apparent absence of fingernail clams in the southern half of the bay. The eastern part of the lake appeared to support the most diverse and well balanced benthic community with amphipods, snails, fingernail clams, midges, caddisflies and mayflies all constituting significant fractions of the community.

In the deeper part of the lake, greater than 17 m (60 feet), the benthos naturally was considerably different from that of the shallower waters. Tubificid worms dominated throughout most of the bottom underlying the hypolimnetic zone. The midge (chironomid) group rates second in abundance and Chaoborus third. Caddisflies and snails were primarily shallow water organisms and therefore did not constitute a significant part of the hypolimnetic fauna. Fingernail clams were found at all the deep water stations but only in small numbers. Amphipods were found at a few stations but again in small numbers.

(c) Tubificid Worms

In general Tubifex tubifex was the dominant species in the deep water areas and this species together with Limnodrilus hoffmeisteri, constituted practically the complete hypolimnetic worm community. In the shallower waters, there was a large number of worm species, although Limnodrilus hoffmeisteri, was the most common and abundant.

(d) Midges (Chironomidae)

Midges, like worms were both common and fairly abundant throughout Lake Simcoe. In the deeper water Procladius and/or Charonomus s.g. Chironomus constituted practically the entire midge population. The shallower waters were characterized by

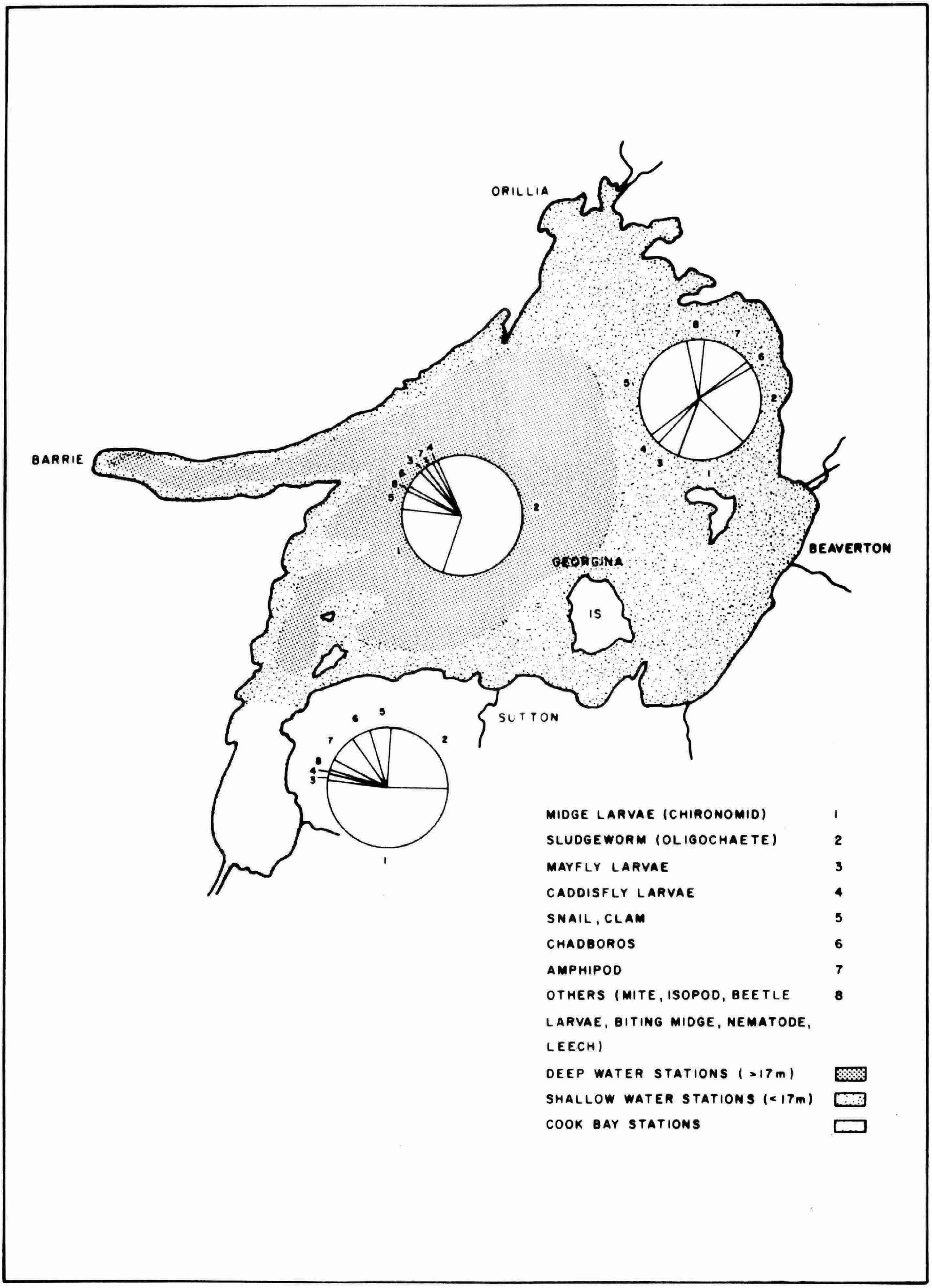

FIG. 5.15 COMPOSITION OF BOTTOM FAUNA COMMUNITIES IN THREE AREAS OF THE LAKE

a wide variety of genera although Procladius again tended to dominate.

(e) Amphipods

Amphipods were found in substantial densities only in the shallow water areas. Only two types of amphipods were recovered - Hyallela Azteca and Gammarus; the latter type was found only at a few locations and in very small numbers.

(f) Mayflies

Both Caenis and Hexagenia were commonly found throughout most of the shallow water areas. These two taxa were particularly predominant in the Shingle Bay area and between Thorah Island and the eastern shoreline. In the Cook Bay area, however, Hexagenia was not found and Caenis was found at only three stations in low numbers.

(g) Caddisflies

Several taxa of caddisflies were found in various sections of Lake Simcoe. Moderate densities were found in the eastern and northern part of the lake with Oecetis and Mystacides constituting the two main genera. In the Cook Bay area only two of the 15 samples collected contained caddisflies; one specimen of Leptocella was found near the mouth of the Holland River and one specimen each of Mystacides and Oecetis was found near the mouth of the Maskinonge River.

(h) Chaoborus

Chaoborus is basically a profundal invertebrate and was commonly found at only the deep water stations.

(i) Molluscs

Neither the fingernail clams nor the snails were identified. Of particular interest was the absence of fingernail clams from the southern samples collected at the southern end of Cook Bay.

5.1.18 Vertical Distribution of Fish

It is generally recognized that fish species such as lake trout and whitefish prefer to inhabit cold water areas(8-12°C) with high dissolved oxygen levels (above 6 mg/l). Studies of the dissolved oxygen and temperature regimes for Lake Simcoe described earlier in this report, show that during a two to three month span in the summer and early autumn the oxygen-rich surface waters reach about 20°C and dissolved oxygen levels in the cold (10°C) bottom waters drop to 2-3 mg/l. In an attempt to determine the location of these cold water species during the critical summer period, echo tracings were made on a number of occasions at four transects in the deep western portion of the lake.

In evaluating the echograms, it was assumed that the large markings were fish and during the period of pronounced vertical stratification the echo markings in the hypolimnetic zone were cold water species.

While the general densities of fish populations varied somewhat from area to area, vertical distribution throughout the surveyed portion of the lake was consistent. Figure 5.16 illustrates the echo tracings obtained across Kempenfelt Bay at a transect about one and one-half miles east of Barrie. Vertical profiles of dissolved oxygen concentrations and temperature are superimposed on the charts.

The results of these echograms show that cold water fish are located throughout the hypolimnetic zone preferring the cold water, lower oxygen conditions over the warmer well-oxygenated surface waters.

5.1.19 Bacteriology

In order to assess the bacteriological quality of water, three tests are normally performed: total coliform, fecal coliform, and fecal streptococcus. Coliform bacteria are always present in large numbers in sewage and are often found in water bodies in the vicinity of waste sources. Fecal streptococci are often present in large numbers in urban and land drainage. These organisms themselves are not harmful to man but high levels may be indicative of the presence of pathogenic organisms or viruses.

The Ministry of the Environment recommends that water used for total body contact recreation contain less than 1000, 100 and/or 20 organisms per 100 ml of total coliform, fecal coliform, and/or fecal streptococcus respectively.

Water used for private water supplies with no treatment should be free from these indicator organisms. If water is chlorinated, total and fecal coliforms and fecal streptococcus should not exceed 100, 10 and/or 1 organism(s) per 100 ml. in the untreated supply (MOE, June 1974).

Bacterial enumerations performed as part of the lake monitoring program indicated that in general, bacteriological quality was satisfactory. In fact, total coliforms seldom exceeded 1000 and were generally less than 100 organisms per 100 ml; fecal coliforms were generally less than 10 organisms per 100 ml and were often zero and fecal streptococcus organisms were almost always zero. When count exceed the criteria they occurred usually in areas adjacent to municipal or tributary stream inputs.

5.2 INTENSIVE WATER QUALITY LAKE SURVEYS

In this section, the findings of 48 and 72-hour intensive water quality surveys in Cook, Kempenfelt and Shingle bays are presented. The principal purpose of each of these surveys conducted during 1971 and 1972 was to measure the effects of major sources of material inputs on the three bays and the open lake.

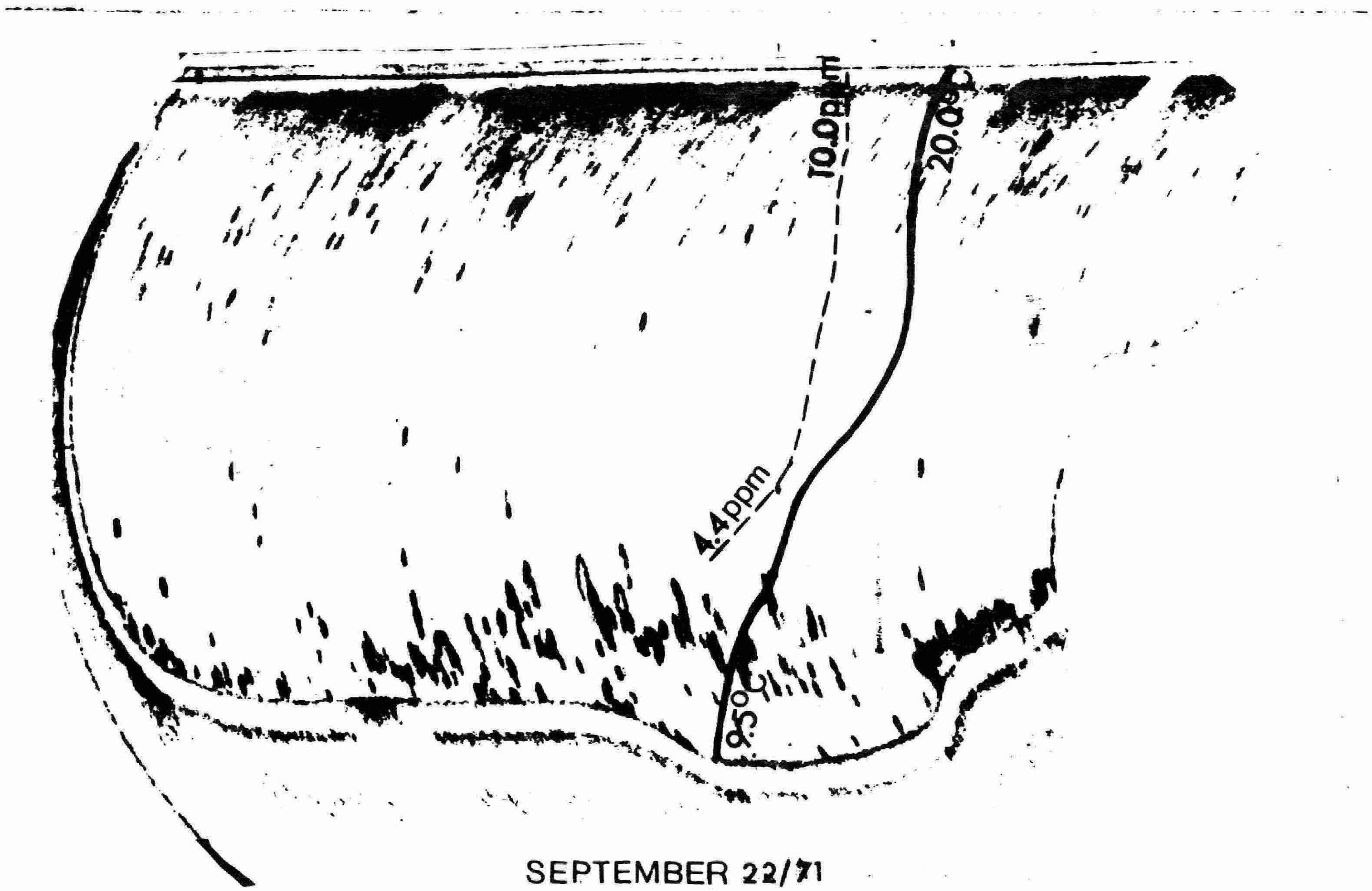

FIG. 5.16 ECHOGRAM ILLUSTRATING FISH DISTRIBUTION

5.2.1 Cook Bay

Five intensive surveys were conducted in Cook Bay over the two year study period. Sampling ranges varied with each survey but generally extended from the mouth of the Holland River north to Cook Bay Shoal. Cook Bay appeared to act as a buffer between the open waters of Lake Simcoe and the organically and nutrient enriched Holland River. Total phosphorus concentrations dramatically exhibited this buffering characteristic of the bay. Based on the five studies, total phosphorus levels at the mouth of the river ranged from 0.11 to 0.69 mg/l. Approximately three kilometers (two miles) north of the river's mouth at a range from Keswick to Gilford, total phosphorus concentrations varied from 0.010 to 0.034 mg/l. Levels at this sampling range were only slightly higher than the open lake concentration of 0.018 mg/l. Nitrogen and BOD_5 concentrations showed about fourfold decreases from the Holland River outlet to the Middle of Cook Bay.

The reduction in organic and nutrient concentrations is evidenced by dense aquatic plant growth and accumulating organic sediment deposits over several hundred hectares around the river's mouth. Bacteriological levels were all within the MOE body-contact recreational criteria.

5.2.2 Kempenfelt Bay

The treated effluent from the 3 MIGD activated sludge sewage treatment plant serving the City of Barrie is discharged via a submerged outfall to the western end of Kempenfelt Bay.

During two of the surveys in 1971, phosphorus removal tests were being carried out at the STP.

Very little effect on the chemical and physical water quality of Kempenfelt Bay was measured as a result of the discharge from the Barrie sewage treatment plant. BOD_5 concentrations were low and exerted no measurable demand on the epilimnetic dissolved oxygen concentrations. Bacteriological levels were within the MOE body contact recreation criteria. Although nitrogen and phosphorus levels were generally low, aquatic weed beds were noted along the south shore of the western end of Kempenfelt Bay. These weed growths could have been promoted by the wastewater discharges from the Barrie area.

As mentioned earlier, phosphorus removal trials were being carried out at the Barrie STP during 1971. During these trials a notable decrease in the level of total phosphorus was measured in the bay. Directly adjacent to the STP outfall, total phosphorus concentrations during the removal experiments were about 0.035 mg/l as compared to 0.055 mg/l when the phosphorus removal facilities were not operating. At a range extending north from Minet Point, about 1½ km (1 mile) east of Barrie, surface total phosphorus levels during the trials ranged from 0.011 to 0.015 mg/l as compared to 0.016 to 0.034 mg/l when phosphorus removal facilities were not in use.

Samples collected during 1974 when phosphorus removal facilities were in full-time operation, showed that total phosphorus levels in the lake closely parallelled the concentrations measured during the 1971 phosphorus removal trials (i.e. 0.029 mg/l near the outfall and 0.016 mg/l at the easterly range).

Except for several slightly elevated levels measured in the immediate vicinity of the City of Barrie STP outfall, bacteriological levels in the bay were low.

5.2.3 Shingle Bay

The treated effluent from the City of Orillia 4.0 MIGD activated sludge sewage treatment plant is discharged to Ben's Ditch which empties into Shingle Bay.

High phosphorus levels (up to 5.5 mg/l) in the STP effluent resulted in concentrations of about 0.08 mg/l in the bay near the mouth of Ben's Ditch. However, these high levels were reduced to about 0.02 mg/l at the range from Victoria Point and to about 0.015 mg/l past Grape Island (see Fig. 2.1).

Bacteriological samples taken during the 1972 surveys showed high coliforms (up to 40,000 org/100 ml) in Ben's Ditch upstream from the STP discharge. These levels were reduced considerably (to about 235 organisms/100 ml) downstream from the STP discharge, indicating a high chlorine residual in the effluent. However, during the past several years, the beach located on Shingle Bay near the mouth of Ben's Ditch has been closed because of bacterial contamination.

In the 1972 surveys, total nitrogen levels did not differ appreciably from Shingle Bay to the open lake (with the exception of the area immediately adjacent to Ben's Ditch); BOD levels did not increase appreciably in Shingle Bay as a result of the STP discharge; dissolved oxygen concentrations were satisfactory in Shingle Bay during the three intensive surveys and during the routine lake monitoring.

5.3 TRIBUTARY RIVER STUDIES

The results of surveys conducted in the vicinity of waste discharges to the major tributaries to Lake Simcoe and the effects of these rivers on water quality of the lake in the vicinity of the river mouths are presented in this section.

5.3.1 Holland River

The Holland River originates in the Oak Ridges moraine, the East Branch to the east of Aurora, the West Branch to the west of the Community of Lloydtown. Through Aurora and Newmarket, the E. Branch drains a clay plain, below Newmarket a till plain, and downstream from Holland Landing a sand plain and the organically rich swamp area.

The West Branch flows through a till plain upstream from the intensively farmed highly organic muck farming region of the Holland Marsh. Downstream from Schomberg, the river empties into two canals bordering the Holland Marsh. These canals are used for irrigation during the summer months. During the spring runoff, land drainage from the south marshland 2880 ha (7120 acres) to the abandoned Holland River bed is pumped into the canal at two locations, one near Highway 11 in Bradford, the other near a tributary entering from the north.

From Bradford to the lake on the West Branch, and from Holland Landing to the lake on the East Branch, the river is navigable. Marinas are located on each branch.

Through Aurora, Schomberg and Newmarket, some water quality impairment was found. Increased levels of BOD_5, nutrients, and coliforms were measured at these locations and low dissolved oxygen levels (5.6 mg/l) were also found through Schomberg. Bogart Creek in Newmarket contained very high bacteriological levels (up to 620,000 organisms/100 ml).

Water quality conditions in the rivers downstream from the Aurora and Newmarket STP's have improved somewhat since 1966 when a water quality survey was conducted on these rivers by the Ontario Water Resources Commission. However, during the 1972 survey degraded water quality conditions (elevated BOD_5, phosphorus, nitrogen and bacteriological levels and decreased dissolved oxygen concentrations) still existed in the Aurora Creek downstream from the Town of Aurora STP. This degradation continued after confluence with the Holland river and water quality conditions had not returned to normal at the south end of Newmarket. As mentioned previously, further water quality degradation occurred through Newmarket.

Downstream from the Newmarket STP, high BOD_5 levels were measured in the stream. Phosphorus and nitrogen levels did not increase in the stream although in Rogers Reservoir, which backs up water to the STP outfall, profuse aquatic growths were found and dissolved oxygen levels fluctuated from 6.8 mg/l at night to 24 mg/l in the afternoon. The high organic and nutrient levels continued in the river to the confluence with the West Holland River.

The recommendations contained in the 1966 report by the Ontario Water Resources Commission entitled "A Water Use Study - Holland River Basin" have not been completely carried out, although improvement in water quality has occurred. The recommendations, related specifically to pollution sources on the eastern branch, stated the BOD_5 loading from the Aurora STP should not exceed 300 lbs/day; the BOD_5 loading from the Newmarket STP should not exceed 100 lbs/day.

In the West Holland River, phosphorus levels increased from approximately 0.4 to about 0.7 mg/l through the south Holland Marsh (at Highway 11). However, these high levels seemed to be atypical as from 1970 to 1973 the water quality monitoring program indicated total phosphorus concentrations consistently less than 0.6 mg/l at the same station (Hwy 11). Organic and

nutrient levels increased slightly as a result from the Bradford STP; however, at the mouth of the river, phosphorus levels had decreased markedly to 0.19 mg/l.

Routine water quality monitoring samples collected from the West Holland River at Highway 11, Bradford, during 1972, indicate that dissolved oxygen levels fluctuated from 3 to 10 mg/l, BOD_5 levels from 1.4 to 11 mg/l and total phosphorus levels from 0.05 to 0.59 mg/l. Similarly, on the Main Holland River at Queensville Road, dissolved oxygen levels fluctuated from 4 to 14 mg/l, BOD_5 levels from 1.4 to 16 mg/l and total phosphorus levels from 0.038 to 0.65 mg/l.

Twenty-four hour sampling indicated that large diurnal-nocturnal dissolved oxygen fluctuations occurred throughout the basin, likely the result of profuse aquatic weed growth noted in all areas.

A survey in the lower end of Cook Bay designed to measure the effects of the Holland River on water quality in the bay indicated that the high concentration of pollutants contained in the river were diluted to levels about the same as the open lake at a distance of about one kilometer from the river's mouth. Phosphorus levels were reduced from 0.14 to 0.015 mg/l, nitrogen from 1.32 to 0.39 mg/l, BOD_5 from 6.0 to 3.5 mg/l and chlorides from 50 to 13 mg/l.

From visual observations and water quality data from each range, it was determined that the water from the Holland River generally tended to flow in an easterly direction after entering the bay and then up the eastern side of the centre of the bay. Nutrients contained in the river water probably contributed to the prolific weed growths in the south and southeastern areas of Cook Bay.

Coliform levels were all well within the MOE body contact recreation criteria in the vicinity of the mouth of the Holland River.

5.3.2 Maskinonge River

The Maskinonge River originates on a till plain to the southeast of Cook Bay. Most of the land in the small drainage basin 62 square kilometers (24 square miles) lies on a till or sand plain. Many of the flat lands in the watershed are being converted from poor general farmlands to sod farms.

The river is navigable from Lake Simcoe for about 1.5 km (1 mile) upstream, due to the backwater from the lake. The mouth of the river has been built up as a major harbour area for yachts and cruisers.

Water quality studies conducted in May and September 1972 show that the chemical-physical quality of the watercourse was generally satisfactory. Phosphorus enrichment as indicated by total phosphorus levels of 0.07 and 0.08 mg/l in branches upstream of built-up areas was likely from intensive

agricultural activities and natural sources. A slight increase to 0.09 mg/l was measured as the river passed through the Community of Jersey, likely the result of urban land drainage. Bacteriological water quality conditions were unsatisfactory at several locations in the basin, exceeding the MOE body contact recreation guidelines.

While the direct causes of bacterial pollution were not positively identified, it is believed that high coliform levels were the result of livestock activities in the upper reaches and urban land drainage through Jersey.

Surveys in the vicinity of the harbour mouth showed generally satisfactory water quality conditions with low levels of BOD_5 91.6 mg/l), total phosphorus (o.04 mg/l), and total nitrogen (0.60 mg/l). Bacteriological levels were within the MOE body contact recreation guidelines. Chemical and physical effects of the Maskinonge River could not be detected in Cook Bay.

5.3.3 Black River

The Black River originates in the Oak Ridges moraine and flows swiftly to the till plain and swamp land downstream from Mount Albert where it slows down considerably. Lignins and tannic acids from the swampy areas give the river a dark appearance. The river is navigable from Lake Simcoe to the dam in the Town of Sutton and a number of cottages are located in this reach.

Water quality conditions in the basin were generally acceptable. Although there were no known direct wastewater discharges in the upstream reaches of the basin, heavy weed growths have occurred in two impoundments, namely Baldwin Pond at Baldwin and the pond in Sutton. These aquatic plant growths were likely the result of nutrient inputs from natural and agricultural sources.

Downstream from Sutton, the river is very wide with little water movement during the summer months. Rooted and floating aquatic plants are abundant but do not detract appreciably from the aesthetic qualities of the river. The Sutton waste treatment lagoon discharges about 0.8 kilometers upstream from the river's mouth, and does not appear to have a significant effect on downstream water quality. Biochemical oxygen demand is quickly satisfied by the oxygen-rich river water and the nutrients are readily utilized by the aquatic plants.

At the mouth, total phosphorus levels decreased from 0.046 mg/l to about 0.028 mg/l one kilometer into the lake. Similarly, total nitrogen decreased from 0.92 to 0.58 mg/l. At about 1500 meters, total phosphorus and nitrogen levels had been reduced to 0.018 mg/l and 0.47 mg/l respectively.

BOD levels were low (less than 2 mg/l) and bacteriological levels were all within the MOE swimming criteria. Chloride levels did not change appreciably from the river to the lake (approximately 12 mg/l).

5.3.4 Pefferlaw Brook

Pefferlaw Brook rises in a swampy area to the northwest of Uxbridge and meanders northerly, mainly through marshland, through the Community of Pefferlaw to Lake Simcoe.

The largest tributary, Uxbridge Brook, rises in the Oak Ridges moraine and flows northerly through the Town of Uxbridge. Treated effluent from the municipal sewage treatment works and uncontrolled urban drainage impaired water quality downstream from Uxbridge by contributing organic and nutrient materials and bacterial contaminants. From Uxbridge to the confluence with Pefferlaw Brook near Udora the stream moves very slowly through swampy land and is characterized by extensive aquatic plant growth resulting in severe diurnal-nocturnal dissolved oxygen fluctuations. Biological survey findings reflected water quality degradation downstream from the Uxbridge STP. A large population of pollution tolerant organisms (sludge worms and midge larvae) dominated the benthic community directly downstream from Uxbridge, but a normal community was re-established within a few kilometers.

Until closing in mid-1972, a metal plating plant in Uxbridge discharged heavy metals to the river via the municipal STP. Copper, chromium, nickel and zinc were present in water samples collected for several kilometers below the town. Samples collected during the summer of 1974 indicated that the concentrations of these metals were low in the river.

Two small communities, Wilfred and Udora, are also located on Uxbridge Brook and the Community of Pefferlaw is located on the Pefferlaw River about two kilometers upstream from Lake Simcoe. These communities do not have sewage collection and treatment facilities and did not have an appreciable effect on the quality of the river.

The water quality of Pefferlaw Brook near its mouth was satisfactory. Levels of BOD_5, chlorides, nitrogen and bacteria were low. Total phosphorus averaged 0.05 mg/l at the mouth but decreased to 0.024 mg/l one kilometer into the lake.

Lake Simcoe in the vicinity of the mouth of the Pefferlaw Brook is very shallow and the lakebed is composed of mud and sand thus necessitating periodic dredging to maintain a navigation channel to the river.

5.3.5 Beaverton River

Chemical and physical water quality conditions in the Beaverton River were generally satisfactory. Low dissolved oxygen levels were measured in the sluggish headwater area near Sunderland, likely the result of benthic oxygen demand of decaying aquatic plants. Phosphorus levels increased through the unsewered Community of Sunderland, likely the result of malfunctioning private waste disposal systems. As the gradient and river velocity increased near Cannington, dissolved oxygen levels returned to near saturation. The Village of Cannington is served by a sewage lagoon with

controlled discharge occurring during periods of high flow in the spring and autumn. With this type of waste disposal system, water quality changes are minimized and do not impair normal water uses.

The Village of Beaverton located near the mouth of the river is also served by a seasonal retention lagoon, however, wastewater is discharged directly to Lake Simcoe via a submerged outfall.

The Beaverton River water quality study conducted during summer low-flow cnditions indicated that there was no appreciable change in physical-chemical water quality as the river passes through Cannington and Beaverton. However, bacteriological levels increased in each community exceeding the MOE body contact recreation criteria, likely the result of urban land runoff and possibly livestock watering between the two communities.

As with the other tributaries along the southern and eastern shores of the lake, the outflow from the Beaverton River has very little effect on water quality of the lake.

Total phosphorus, nitrogen and BOD_5 levels were only slightly higher in the river than the open lake. Chloride levels were the same as in the lake and bacteriological levels in the harbour area were generally very acceptable.

5.3.6 Talbot River-Trent Canal

The headwaters of the Talbot River are in a limestone plain to the north of Canal Lake. Downstream from Canal Lake the river drains sand and clay plains. The lower Talbot River is the prime pickerel spawning area in the Lake Simcoe Basin. There are no major sources of contamination on this system and water quality conditions are very good with low levels of organic, nutrient and bacterial pollutants. Water quality at the mouth is, in fact, very similar to open lake conditions.

5.4 MISCELLANEOUS STUDIES

5.4.1 Intensive Shoreline Water Quality Studies

In both the 1972 and 1973 shoreline studies, total phosphorus concentrations were slightly higher along the shoreline (i.e. generally within 25 meters of shore) than in the open waters. Some areas of the nearshore waters contained higher levels of phosphorus than others, namely in Shingle Bay, the west end of Kempenfelt Bay, the east and west shorelines of Cook Bay and other highly developed areas of the shoreline (eg. Jackson's Point), and where canals were dredged out to provide access to the lake for a number of cottages (eg. Lagoon City, Crescent Harbour).

It appears from this study that extensive water quality impairment does not occur as the result of cottage development. At individual stations, spring and fall sampling

showed that phosphorus concentrations did not change appreciably. Bacteriological levels were in almost all cases within the MOE swimming criteria in both spring and fall, but were generally lower in the fall than in the spring.

5.4.2 Oxygen Uptake Studies

(a) Lakebed Composition

The bottom of Lake Simcoe is composed primarily of sand and rock in the shallow and exposed areas of the lake and mud in the deeper and sheltered areas. It is interesting to note that the zone of predominantly mud bottom closely parallels the hypolimnetic zone, i.e. 18 meter (60 foot) contour. Extensive areas of mud were also found in Cook Bay and in the lee of Georgina and Thorah islands. Figure 5.17 outlines the areas of sediment deposition and indicates the general composition of the lake bottom.

Samples of lake sediment were collected at about 90 locations throughout the lake during 1971 and were analysed for oxidization materials (i.e. primarily organic content). Generally, bottom samples composed primarily of lake muds demonstrated 8 to 12 percent loss on ignition. Samples from the rock, gravel and sand east shoreline, south shoreline and Kempenfelt Bay shoreline showed generally less than 2 to 3 percent volatile content. Detailed loss on ignition data for Lake Simcoe are presented in Figure 5.18.

(b) Benthic Oxygen Demand

The method employed for determining the oxygen uptake rates of lake bottom sediments was described previously in Section 4.1.3 (b). The results of this study show that the benthic oxygen demand in the deeper areas of the lake (over 18 metres) averaged about 0.65 grams of oxygen per square meter per day (1.4×10^{-5} lbs. of oxygen per square foot per day). The rates measured compared favourably with studies conducted on Ramsen Lake in Sweden, (Edburg 1973) a lake with similar levels of organic matter in the sediment (10 to 12 percent loss on ignition).

Benthic respiration rates measured in Cook Bay were somewhat lower than the deeper mud areas, averaging about 0.32 grams oxygen per square meter per day. Rates measured in the north end of the lake, near Trout Shoal and The Narrows were higher than all other locations, at 1.8 and 3.1 grams of oxygen/square meter/ day respectively. The lower rates measured in Cook Bay and higher rates found in the north end of the lake cannot be explained without further detailed investigation but it should be noted that both the low and high rates are not greatly out of line with the normal benthic respiration rate range.

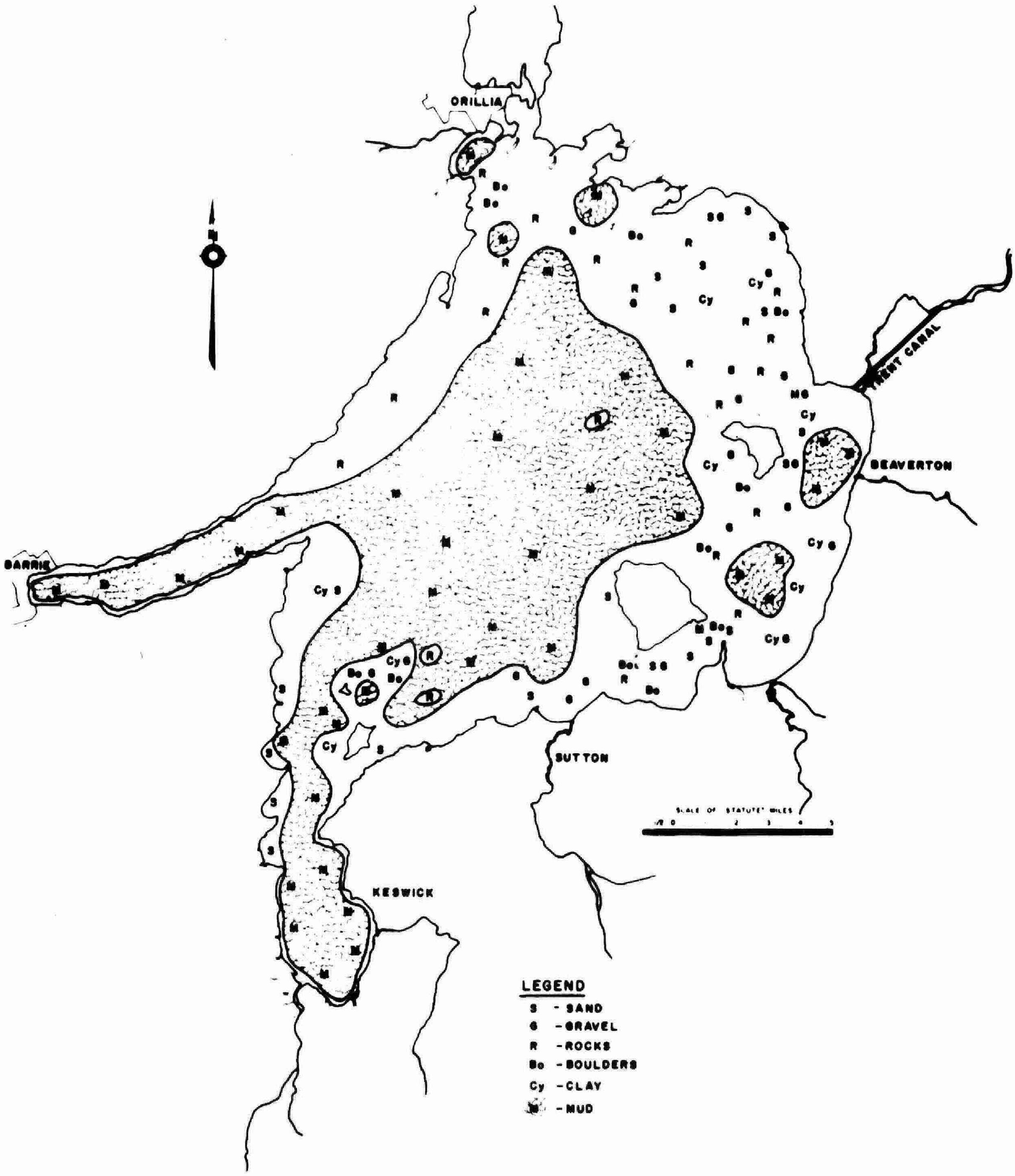

FIG. 5.17 LAKE BOTTOM COMPOSITION

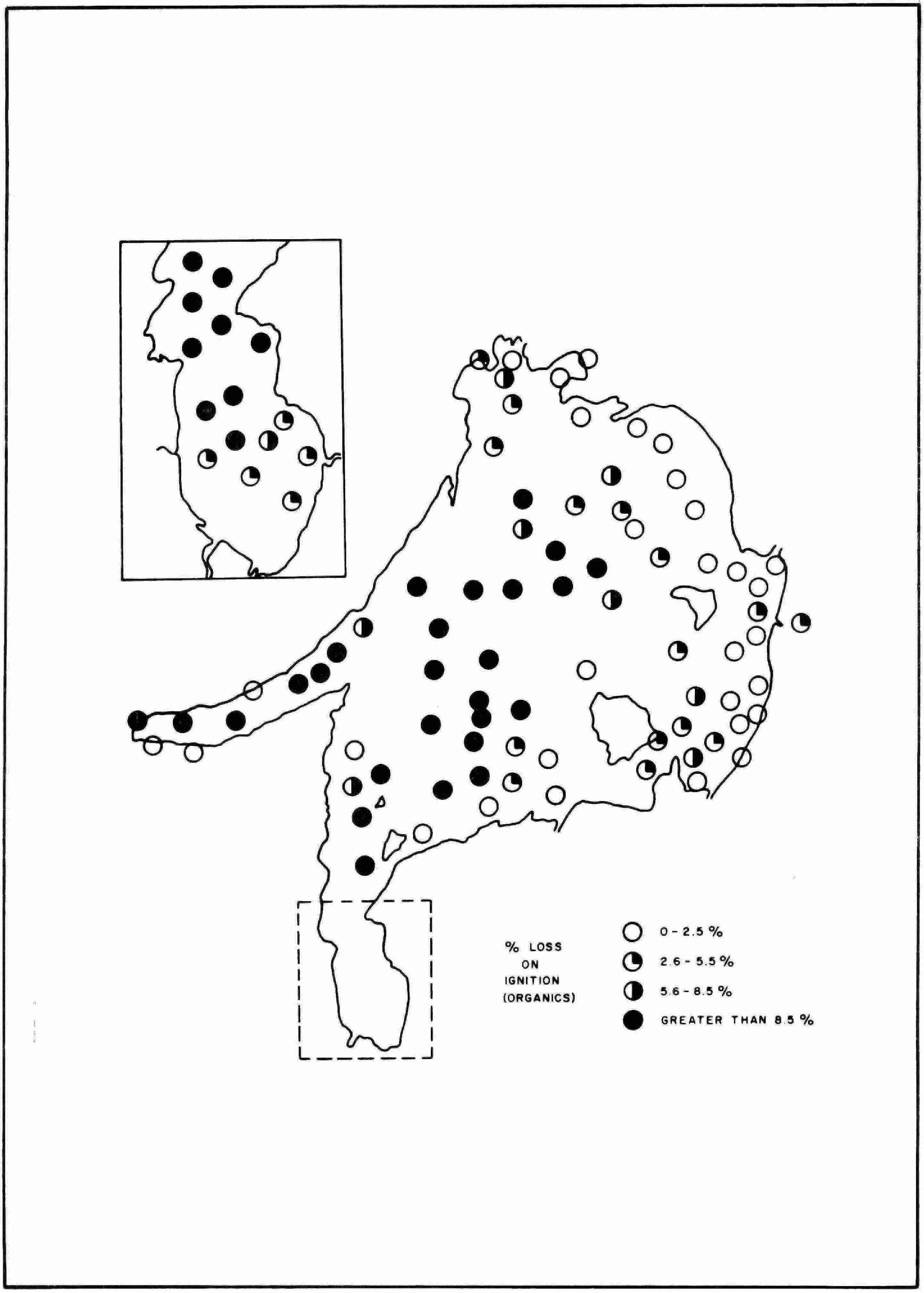

FIG. 5.18 ORGANIC CONTENT OF THE SEDIMENTS

CHAPTER 6 - MATERIAL INPUTS

6.1 LOADINGS

Annual loadings were calculated for all significant material inputs to Lake Simcoe and sources were categorized under the following headings: municipalities; major tributary streams; precipitation; direct land drainage (i.e. loadings not included in major tributaries); and cottages. In the following paragraphs, the methods of material input calculations and the tabulation of major loadings are presented.

6.1.1 Municipalities

Material loadings from municipal sewage treatment plants discharging directly to Lake Simcoe were calculated from plant operation records and files, and in consultation with appropriate staff of the Ministry of the Environment. Loadings are presented in Table 6.1.

In 1974, phosphorus removal programs were implemented at all municipal sewage treatment plants in the basin. For a general comparison of phosphorus loadings prior to and following phosphorus removal, measured 1972 loadings were compared to calculated post-phosphorus removal loadings assuming a total phosphorus concentration of 1.0 mg/l in the final effluent.

6.1.2 Major Tributary Streams

During the Lake Simcoe survey period all major rivers and streams discharging to the lake were sampled on a routine monthly basis with intensified sampling during the spring runoff period. Streamflow records were obtained from existing flow gauges maintained by the Water Survey of Canada and the Ministry of the Environment. Where streamflow records were not available, data from gauges on similar nearby streams were pro-rated.

Average water quality conditions for 1972 are presented in Table 6.2 and the 1972 mean loadings from the major tributary streams are presented in Table 6.3

Nitrogen and phosphorus data for the Holland River were obtained from a thesis by K. H. Nichols (1972) as they represented year-round sampling at the mouth of the river.

6.1.3 Precipitation

Rainfall and snowfall records for Keswick and Orillia were obtained from the Canada Department of the Environment and the data were averaged to obtain an estimate of the precipitation falling directly on Lake Simcoe. These values for 1972 were: rainfall - 62.2 cm (24.5 inches) and snowfall 26.7 cm (10.5 inches), expressed as equivalent rainfall.

Precipitation chemistry was obtained from a report on research conducted on Clear Lake in Haliburton County (Schindler &

TABLE 6.1

MUNICIPAL SEWAGE TREATMENT PLANT LOADINGS (1972)
(METRIC TONS PER YEAR)
(IMPERIAL TONS PER YEAR IN BRACKETS)

Municipality	Q MIGD	BOD	Total Nitrogen	Total Solids	Suspended Solids	Total Phosphorus	
						With P Removal	Without P Removal
Barrie	3.47	92.8 (102.6)	92 (101)	5220 (5760)	115 (127)	5.8 (6.4)	19.5 (21.5)
Orillia	2.55	50 (55.0)	63 (70)	2480 (2750)	34 (37)	4.3 (4.7)	18.1 (20.0)
Beaverton	28 Total	1.0 (1.1)	0.36 (0.4)	80 (87)(e)	2.0 (2.2)	0.13 (0.14)	0.2 (0.2)
Sutton	0.2	9.0 (9.9)	5.0 (5.5)	207 (228)	9.1 (10)	0.36 (0.4)	1.8 (2.0)
Keswick	2 (proposed)	- -	- -	- -	- -	1.8 (2.0)	- -

TABLE 6.2

TRIBUTARY STREAM WATER QUALITY DATA - 1972 AVERAGES
(mg/l unless specified)

Stream	D.O.	BOD_5	Bacteria per 100 ml *			Phosphorus		Nitrogens				Solids		Turb. J.T.U.	Cond umhos/cm³	Chlorides	Phenols ppb
			Tot Coli	Fecal Coli	Fecal Strep	Tot	Sol	F.A.	Kjel	Nitrite	Nitrate	Tot	Susp				
Schomberg R. @ Hw. 11	9.0	3.3	540	19	29	.27	.13	.21	1.31	.045	1.06	437	17	13	598	44	2.7
Holland R. @ Queensville Rd.	10.0	5.8	1610	154	144	.42	.16	.70	2.21	.088	1.28	470	37	19	707	83	4.5
Maskinonge R. (Jersey R.)	9.5	2.9	332	20	24	.086	.027	.05	.83	.011	.38	293	10	9	429	26	3
Black R. @ Sutton	8.9	1.7	138	19	33	.054	.014	.04	.73	.006	.19	269	5	4	401	14	3.5
Pefferlaw Bk.	10.4	1.8	114	10	27	.056	.013	.04	.60	.007	.29	278	11	10	406	10	3.6
Beaverton R.	10.5	1.4	1020	78	44	.064	.025	.07	.78	.009	.41	295	10	10	425	16	4
Talbot R.	10.6	1.5	354	13	43	.039	.007	.06	.51	.005	.11	201	7	9	300	9	3
Hawkestone Ck.	11.1	1.3	1050	116	115	.034	.010	.03	.53	.008	.28	394	6	8	354	8	3
Outlet @ Atherley	12.0	1.4	10	1	2	.035	.005	.02	.42	.002	.02	197	6	6	303	12	2
Severn R. @ Washago	12.0	1.2	21	2	3	.019	.006	.03	.40	.003	.03	196	5	4	296	12	2

* Geometric Means

TABLE 6.3

MATERIAL LOADINGS TO LAKE SIMCOE - RIVERS (1972)
(METRIC TONS PER YEAR)
(IMPERIAL TONS PER YEAR IN BRACKETS)

River	Flow (cfs)	BOD_5	Total Nitrogen	Solids		Total Phosphorus		Soluble Phosphorus	
				Total	Suspended	1972	*	1972	*
Holland R.	133	712 (785)	398** (440)	37,550 (41,400)	2,980 (3,280)	37.4** (41.0)	28.1 (31.0)	15.3** (16.8)	14.0 (15.4)
Maskinonge R.	16	42 (46)	17.4 (19.2)	4,190 (4,620)	143 (158)	1.3 (1.4)	1.3 (1.4)	0.39 (0.43)	0.39 (0.43)
Black R.	91	138 (152)	75.6 (83.4)	21,880 (24,120)	406 (448)	4.4 (4.8)	4.4 (4.8)	1.2 (1.3)	1.2 (1.3)
Pefferlaw Bk.	170	275 (303)	136.8 (150.8)	42,240 (46,570)	1,670 (1,840)	8.5 (9.4)	6.7 (7.4)	2.0 (2.2)	1.8 (2.0)
Beaverton R.	104	130 (143)	111.6 (123.0)	27,430 (30,240)	930 (1,025)	6.0 (6.6)	5.7 (6.3)	2.4 (2.6)	2.1 (2.3)
Talbot R.	145	194 (214)	80.4 (88.6)	26,050 (28,720)	907 (1,000)	5.1 (5.6)	5.1 (5.6)	0.9 (1.0)	0.9 (1.0)

*Following phosphorus removal at sewage treatment plants.

**Nichols, 1972

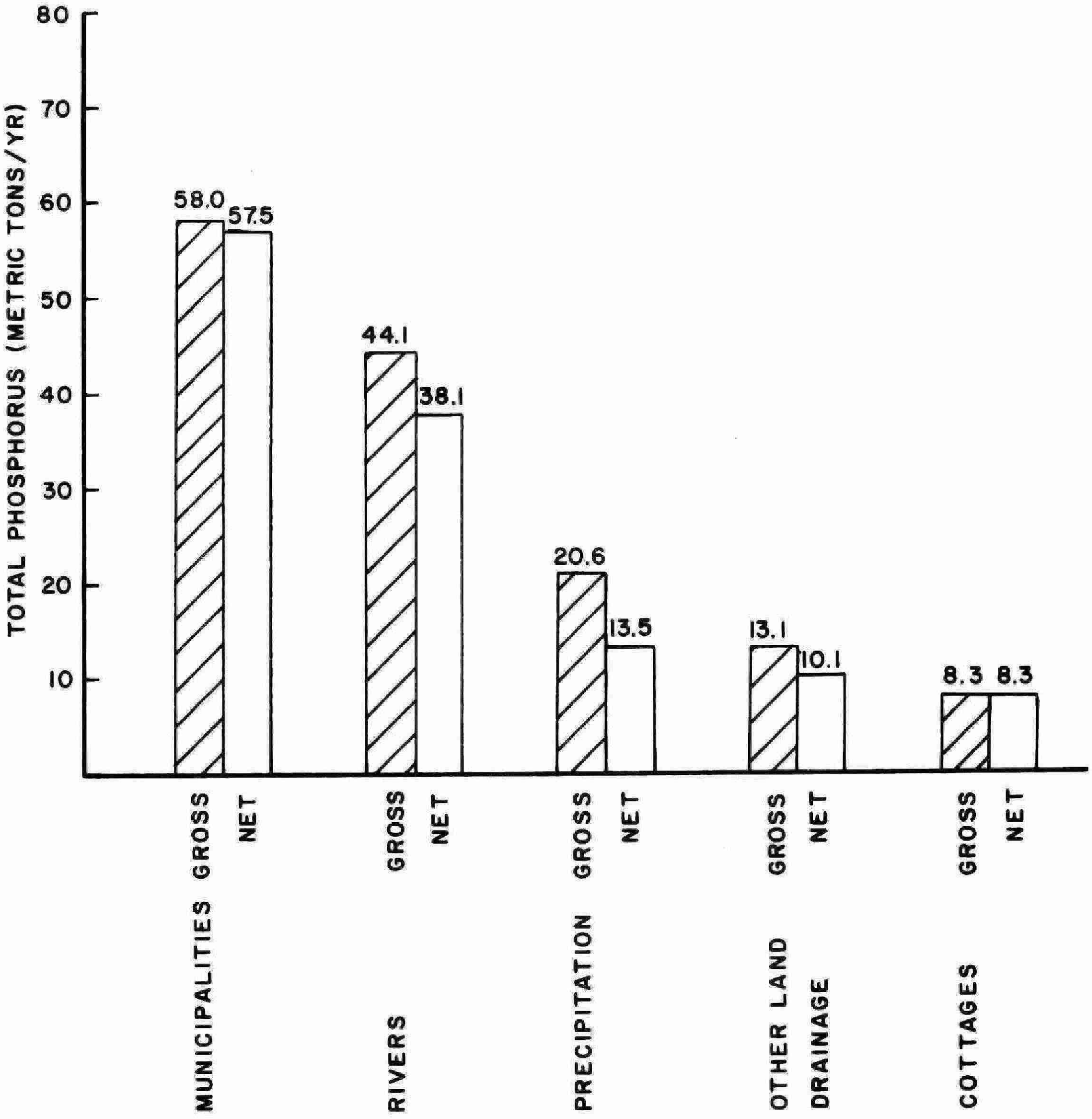

FIG. 6.1 A COMPARISON OF GROSS AND NET TOTAL PHOSPHORUS LOADINGS TO LAKE SIMCOE

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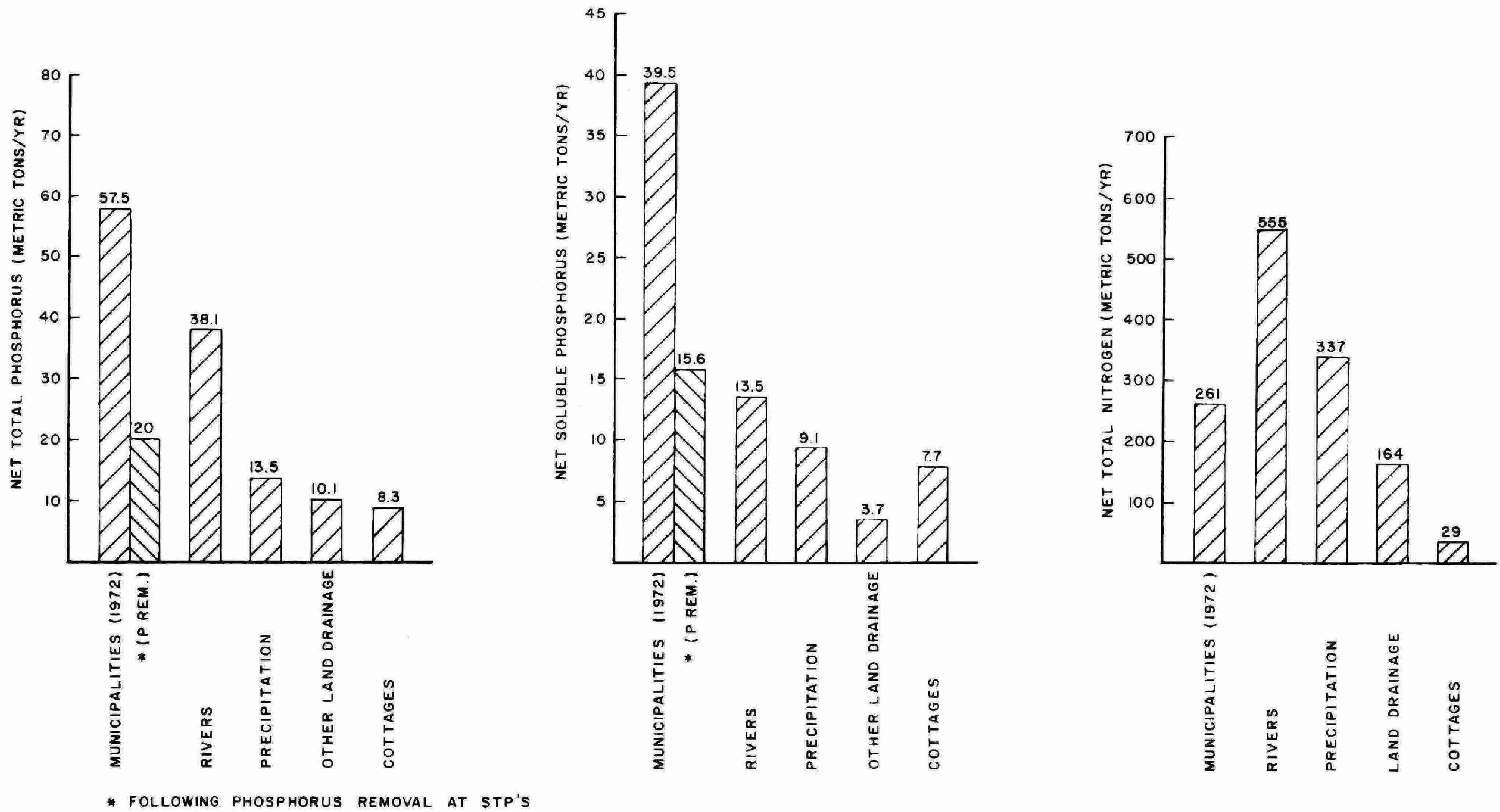

FIG. 6.2 PHOSPHORUS AND NITROGEN LOADINGS TO LAKE SIMCOE

Nighswander, 1970). The authors believe that the precipitation quality in this area should on the average be similar to precipitation quality in the Lake Simcoe Basin. Values were:

	Rainfall	Snowfall
Total Phosphorus	0.020 mg/l	0.060 mg/l
Soluble Phosphorus	0.018 mg/l	0.012 mg/l
Total Nitrogen	0.80 mg/l	0.80 mg/l

Total precipitation falling directly on Lake Simcoe contributed 20.6 metric tons (22.7 T) per year of total phosphorus and 515 metric tons (568 T) per year of total nitrogen. Precipitation quantity is equivalent to a stream with a mean daily flow of 720 cfs.

6.1.4 Direct Land Drainage

In this report direct land drainage was considered to be all land drainage other than that directly measured in major tributaries (i.e. small streams, rivulets, ditches, etc.).

From Lake Simcoe tributary stream monitoring records, phosphorus and nitrogen yields, excluding municipal and industrial sources, were calculated and applied to land areas draining directly to the lake. Estimates of yields obtained in this manner were: total phosphorus 15.3 $kg/km^2/yr$ (88 $lb/mi^2/yr$), soluble reactive phosphorus 4.0 $kg/km^2/yr$ (23 $lb/mi^2/yr$), and total nitrogen 282 $kg/km^2/yr$ (1620 $lb/mi^2/yr$). An average streamflow equivalent of 0.357 cfs/km^2 (0.93 cfs/mi^2) was calculated from the tributary streamflow data.

From the 849 square kilometers (326 square miles) of the Lake Simcoe Basin considered to be discharging directly to the lake, an inflow of slightly over 300 cfs was calculated. This drainage contributed 13.1 metric tons/year (14.4 tons/yr) of total phosphorus and 240 metric tons/yr (264 tons/yr) of total nitrogen.

6.1.5 Cottages

A review of literature and STP data indicates that raw municipal sewage contains the equivalent of about 1.32 kg/cap/yr (2.9 lb/capita/year) of total phosphorus and about 4.0 kg/cap/yr (8.8 lb/capita/year) of total nitrogen. These figures include some industrial inputs, laundry water, dish water, and garbage disposal unit wastes. These sources can, for the most part, be neglected when calculating the loadings to cottage septic tanks around Lake Simcoe. The yields, therefore, were adjusted to 0.9 kg/cap/yr (2.0 lb/capita/year) of total phosphorus and 3.2 kg/cap/yr (7.0 lb/capita/year) of total nitrogen.

From the cottagers' questionnaire, 83 percent of the approximately 10,000 cottages around the lake dispose of their sanitary wastes to septic tank systems and the bulk of the remainder use pit privies. The average number of days used

per cottage was 90 and the number of people per cottage was 4.5. The septic tank loading was, therefore, the equivalent of 9200 man-years.

The effectiveness of waste treatment in septic tank tile field systems varies significantly from area to area and probably from cottage to cottage. For a gross comparison of the significance of nutrient inputs from private septic tank systems to other sources of Nitrogen and Phosphorus in the basin, the worst possible situation was employed, that is, no nitrogen or phosphorus removal occurring and all of these materials ultimately reaching the lake. The total loadings from septic tanks in this situation would be 29 metric tons (32 tons)/per year of nitrogen and 8.3 metric tons (9.2 tons) per year of total phosphorus.

6.2 DEVELOPMENT OF THE NET LOADING CONCEPT

Since low volume/high concentration waste inputs (eg. STP's) increase concentrations in the lake to a much greater extent than high volume/low concentration inputs (eg. unpolluted rivers) net loadings were calculated for all sources to the lake. The net loading concept permits a more realistic comparison of the significance of material inputs.

In the past net inputs were calculated as the difference between the gross input and the amount of nutrient displaced at the outlet in an equivalent flow. This is expressed mathematically as: net input = volume of input x (concentration of input - concentration at outlet) or

$$L_n = V_i \ (C_i - C_0)$$

However, this equation does not take into account the loss of water through evaporation without an associated loss of materials (nutrients, solids, etc.) from the lake. To develop the equation incorporating this factor it is necessary to establish the relationship between outflow at The Narrows and Total inflow. A hydrologic balance of Lake Simcoe is presented in Table 6.4.

From the table is is evident that the sum of the inflows, 1695 cfs, generates an outflow at The Narrows of only 1170 cfs (or 69 percent of the inflow). The balance was lost primarily via evaporation.

Applying the outflow to inflow ratio of 0.69 to 1 (i.e. 69%) to the original equation, the following net loading equation was obtained: Net loading = input volume x input concentration minus 0.69 x input volume x output concentration

$$L_n = V_i . C_i - 0.69 \ V_i . C_o$$

The net loadings to the lake were calculated; Figure 6.1 illustrates gross and net total phosphorus loadings to Lake Simcoe.

Table 6.4 Hydrologic Balance (1972)

cfs. cfs.

Source/Sink	Inflow	Outflow
Streams	659	1170
Sewage Treatment Plants	12	-
Direct land drainage	304	-
Precipitation	720	-
Evaporation	-	530[1]
Groundwater[2]	unknown	unknown
Total	1695	1700

6.3 NET LOADINGS

The tributary stream loadings, sewage treatment plant inputs and other sources of materials discussed in this chapter contribute significant quantities of organic matter, suspended and dissolved solids and nutrient materials (nitrogen and phosphorus) to Lake Simcoe. Total net loadings for the key water quality parameters are summarized in Table 6.5.

Table 6.5 Summary of Net Material Inputs to Lake Simcoe

5-day BOD	-1180 metric tons/yr (1300 tons/yr)
Suspended Solids	-7000 metric tons/yr (7700 tons/yr)
Dissolved Solids	-109,000 metric tons/yr (120,000 tons/yr)
Total Nitrogen*	-1390 metric tons/yr (1535 tons/yr)
Total Phosphorus*	
-with P removal at STP's	-89 metric tons/yr (99 tons/yr)
-without P removal at STP's	-127 metric tons/yr (140 tons/yr)

*Nitrogen and Phosphorus loadings from the major sources are summarized graphically in Figure 6.2.

The effects of these materials and other pollutants such as bacteria on the quality of Lake Simcoe are discussed in detail in Chapter 7.

[1] *Evaporation calculated using 0.66 m/year (Bruce and Weisman, 1966)*

[2] *Groundwater inflow or outflow were not measured or estimated but from the hydrologic balance it appears that groundwater inflow approximately equals groundwater outflow*

CHAPTER 7

SIGNIFICANCE OF MATERIAL INPUTS ON WATER QUALITY

When considering the effects of material inputs on the water quality of Lake Simcoe, two entirely distinct lake zones must be examined. The surface water or epilimnetic zone (from the surface to about 18 meters deep) is where most water use activities occur (i.e. recreation, water supply, waste disposal and transportation). The hypolimnetic waters (18 meters from the surface to the lakebed) are much cooler than the surface waters during the summer stratification period and therefore provide a more desirable habitat for cold water fish species. Aside from some angling and scuba diving, man's activities do not directly extend into this zone.

7.1 SURFACE WATERS

Material inputs, as described in Chapter 6, from tributary streams, sewage treatment plants, land drainage, precipitation and private waste treatment systems, contribute directly to this zone and in the following sections the significance of the major pollutants and their effects on the aquatic environment are described.

7.1.1 De-oxygenating Materials

Oxygen demanding organic materials as measured in the BOD_5 test are discharged to Lake Simcoe at the rate of 3230 kilograms per day (7130 pounds per day). The available dissolved oxygen in the surface water zone of the lake is 79 x 10^6 kilograms (174 x 10^6 pounds), or more, at any time and any oxygen consumed is quickly replenished by the transfer of oxygen from the atmosphere, at the lake's surface or through photosynthesis of aquatic plants. It is obvious that the satisfaction of BOD_5 from individual sources (e.g. sewage treatment plant effluents, tributary streams, etc.) generally occurs in the vicinity of the discharge point and may draw down the dissolved oxygen concentration in this localized area. However, oxygen measurements made during the four surveys indicate that, even in the vicinity of major discharges, oxygen depletion was undetectable.

Some organic material, particularly from tributary streams, and to a lesser extent sewage treatment plants, may be in particulate form and quickly settle to the lakebed or be translocated by gravity and lake currents from the shallow areas to the deeper zone. In the shallow areas where these deposits accumulate (e.g. Cook Bay and east of Georgina Island) the oxygen demand exerted by the deposits is readily satisfied by the oxygen rich epilimnetic waters. Benthic oxygen demand exerts a significant effect on the oxygen

resources of the hypolimnetic waters and is dealt with in detail in Section 7.2.

7.1.2 Solid Materials

Dissolved solids (i.e. carbonates, bicarbonates, chlorides, sulphates, phosphates, nitrates, iron and traces of other substances) are introduced to Lake Simcoe through all material inputs. While dissolved salts may affect the use of a watercourse for domestic and industrial water supply, irrigation and livestock watering, the total dissolved solids level measured in Lake Simcoe (approximately 190 mg/l) would not affect the above uses. Aside from sudden increases that might occur in the immediate vicinity of wastewater sources, dissolved solids likely do not affect the aquatic life of Lake Simcoe.

Suspended solids loadings to the Lake Simcoe basin originate primarily from sewage treatment plant discharges and urban and rural land drainage. While the concentration in some of the tributary streams is fairly high, giving the stream a turbid appearance, the solids quickly settle or are dissipated in the lake.

7.1.3 Nitrogen and Phosphorus Inputs

The macro-nutrients nitrogen and phosphorus are key parameters in the assessment of the water quality of Lake Simcoe. As described in Sections 5.1.1 and 5.1.2 the availability of these materials directly relates to the growth of free-floating and attached algae and rooted aquatic plants in the lake and its tributary streams.

(a) Nitrogen

A breakdown of the major sources of nitrogen is presented in Figure 7.1. The largest single source of nitrogen is the Holland River system followed by the Pefferlaw Brook, Beaverton River, Talbot River and the Maskinonge River. The diffuse sources, precipitation and direct land drainage, also contribute significant amounts of nitrogen to the lake. Blue-green algae such as Anabaena can obtain nitrogen directly from the atmosphere, thus increasing the total nitrogen input to the lake. The magnitude of this source was not estimated during the Lake Simcoe study.

While there are significant inputs of nitrogen to the lake the concentration of nitrogen in the open water areas of Lake Simcoe is low and indicative of oligotrophic conditions.

The following figure illustrates the relative level of nitrogen in Lake Simcoe compared to other lakes on Ontario.

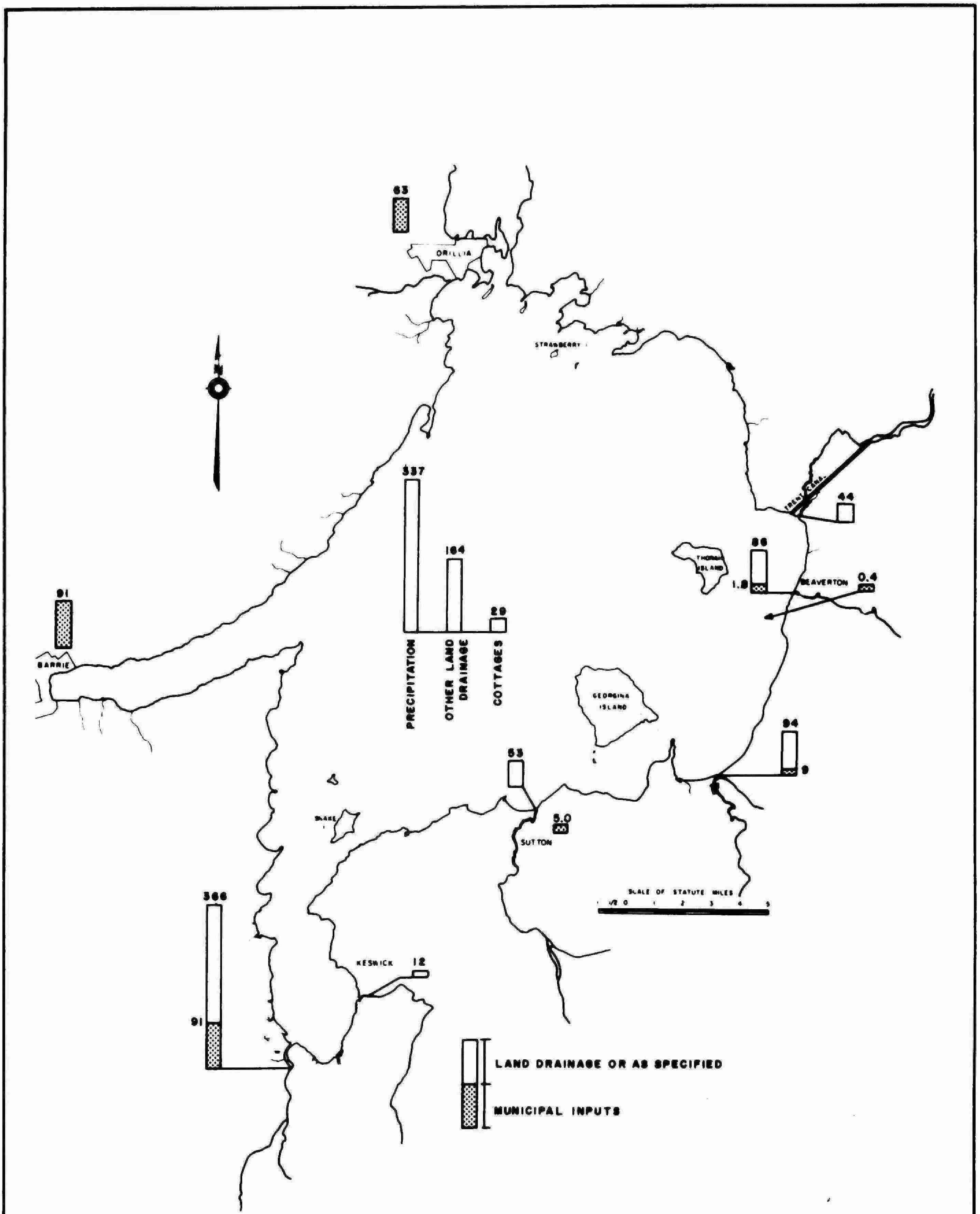

FIG. 7.1 NET TOTAL NITROGEN INPUTS (METRIC TONS/YR)

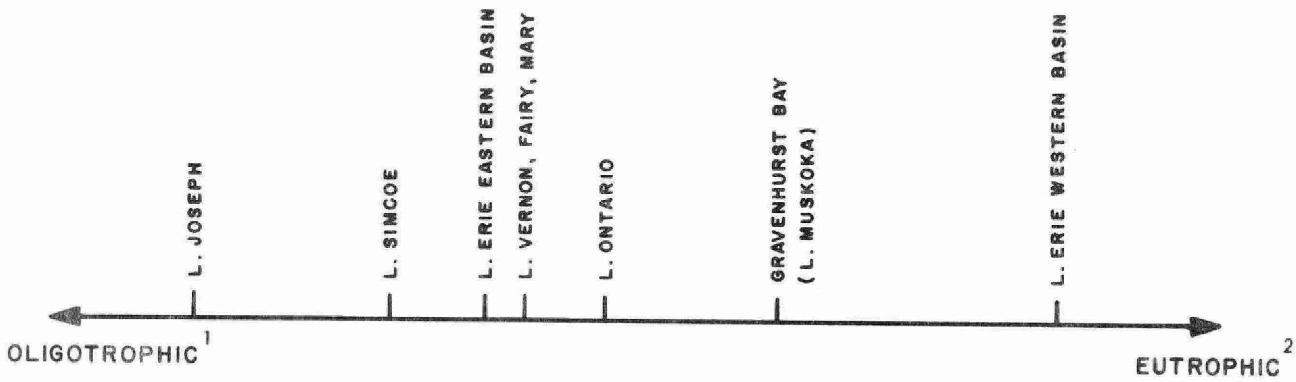

FIG. 7.2 RELATIVE TOTAL NITROGEN CONCENTRATIONS IN SOME ONTARIO LAKES

(b) Phosphorus

The Holland River System, the Barrie STP and the Orillia STP are the largest sources of total phosphorus to Lake Simcoe. As shown in Figure 7.3, the other river systems, precipitation, direct land drainage and cottages all contribute lesser, but significant loadings of phosphorus to the lake. As with nitrogen the concentration of phosphorus in the open-water sections of Lake Simcoe is low. It is also important to note that the build-up of phosphorus in the bottom waters of the lake is small even during the summer stratification period, indicating that phosphorus release from the sediments is insignificant. Phosphorus leaching would not be expected in Lake Simcoe where minimum hypolimnetic DO levels do not generally fall below 2.5 mg/l. (Many scientists believe that phosphorus is released from the sediments when bottom waters approach anoxic conditions.)

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[1]*Oligotrophic lakes or basins can be generally characterized as having low concentrations of nutrient materials, little plant and algal growth thus low turbidity levels and abundant dissolved oxygen throughout the lake.*

[2]*Eutrophic lakes or basins are usually characterized as being rich in nutrient materials, having heavy plant and algal growth, thus a turbid appearance; the deeper water, during periods of restricted circulation, becomes deficient or void of oxygen as a result of the decomposition of dead, aquatic biomass.*

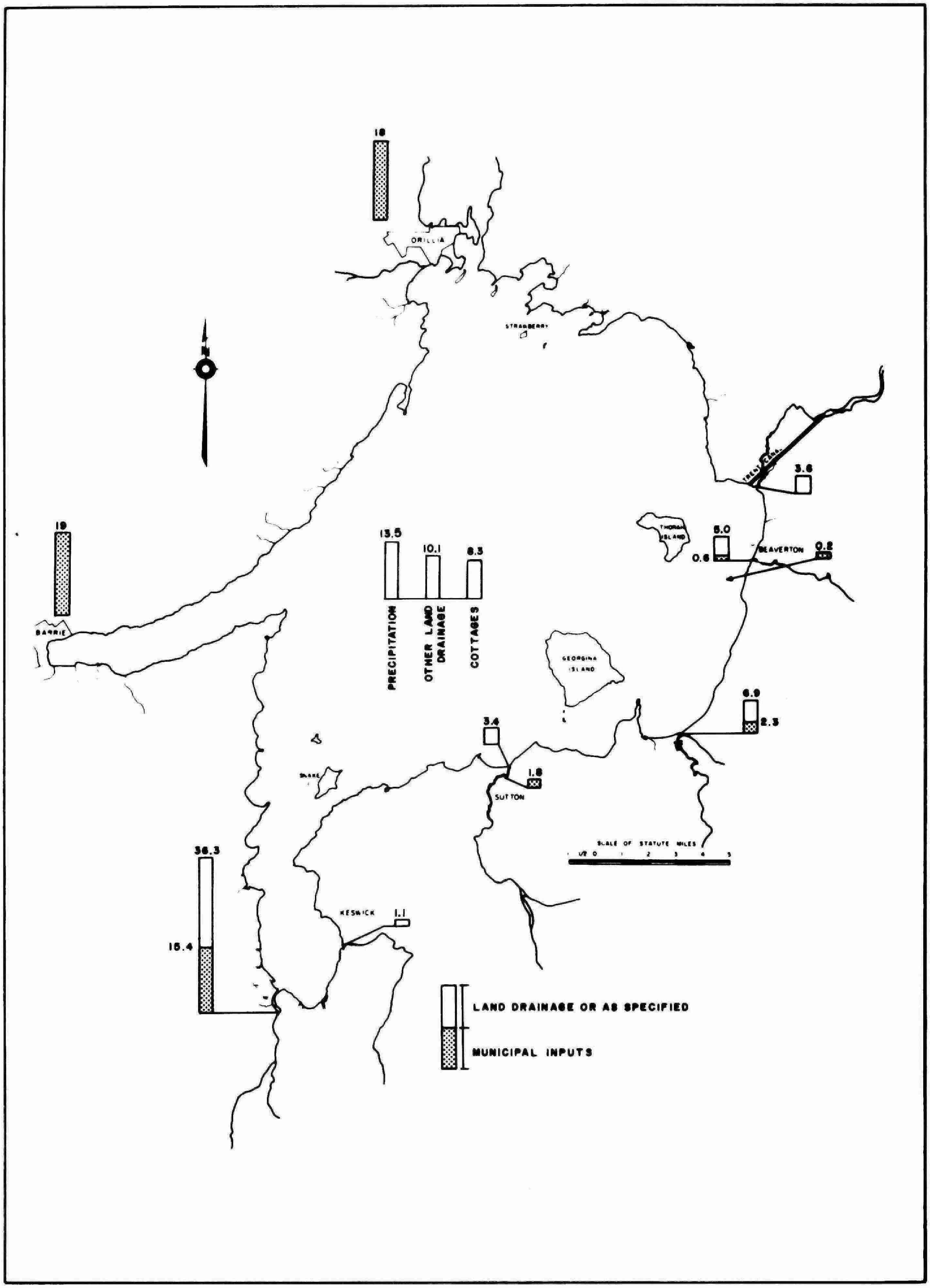


FIG. 7.3 NET TOTAL PHOSPHORUS INPUT (1972)
(METRIC TONS/YR)

Enclosed, sheltered areas in the lake in the vicinity of major phosphorus inputs (i.e. Lower Cook Bay and Shingle Bay) have appreciably higher concentrations of phosphorus than the open waters as outlined in Section 5.1.1. Massive aquatic weed and algal growths can be observed in these areas at most times; these bays can be considered in the eutrophic range.

The western end of Kempenfelt Bay does not exhibit exceptionally different phosphorus concentrations from the open lake. However, some aquatic plant and algal growths do occur, likely the result of controlled or uncontrolled wastewater discharges from the Barrie area. The following figure compares phosphorus levels in the offshore regions of Lake Simcoe to levels in some other southern Ontario lakes.

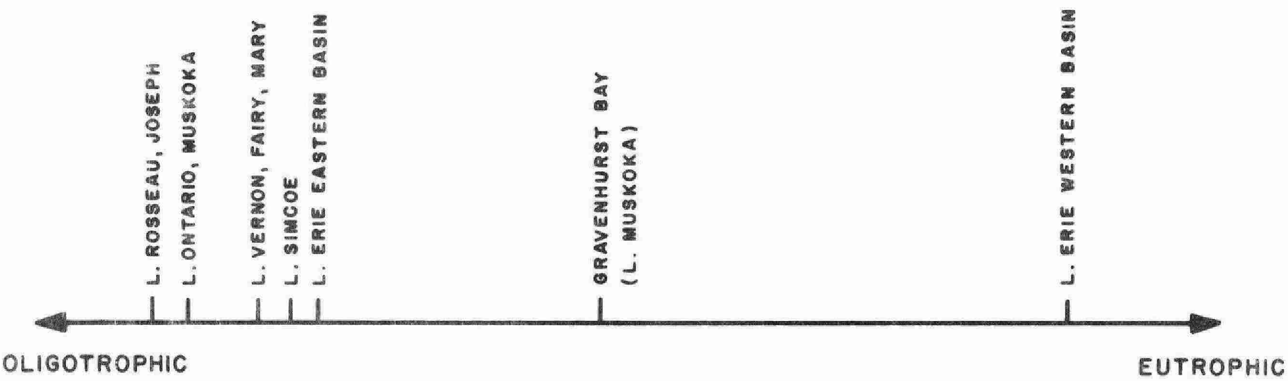


FIG. 7.4 RELATIVE PHOSPHORUS CONCENTRATIONS IN SOME SOUTHERN ONTARIO LAKES

(c) Aquatic Plant and Algal Growth

Although the phosphorus concentrations in the open-water areas of Lake Simcoe appear to be quite low, algal growth, as evidenced by several lake-wide algal scums observed since 1971 and increased occurrence of attached algae (periphyton) growth along previously clean shorelines, are beginning to detract from the aesthetic and recreational enjoyment of the lake.

Phytoplankton

In terms of assessing the trophic status of a lake, the productivity rate on a volumentric basis is most valuable, areal rates tend to underestimate the differences between oligotrophic and eutrophic lakes due to the increase in eutrophic depth in an oligotrophic lake. To compare the phytoplankton productivity rates at a number of locations, the maximum productivity rates within the euphotic column are normally used; each time productivity is measured at a particular sampling station, a number of individual measurements are made through the euphotic column and the maximum

productivity values for the column can be used for comparative purposes. A mean of these maximum values at various stations throughout the lake can then be used to compare "mean maximum" carbon fixation rates between lakes. For Lake Simcoe, the mean maximum rate of carbon uptake varied from 1.0 mgC per cubic meter per hour in the middle of Kempenfelt Bay to 2.2 mgC per cubic meter per hour in the middle of Cook Bay. The overall mean maximum for the lake was 1.5 $mgC/m^3/hr$. A comparison of the productivity of Lake Simcoe to some other lakes is presented in Table 7.1.

Table 7.1: A Comparison of Phytoplankton Productivity in Various Lakes

Lake	Mean Maximum Carbon Fixation Rate ($mgC/m^3/hr$)
Lake Superior - bays	0.5
- open lake	0.6
Lake Joseph	0.6
Lake Rosseau	1.2
Lake Huron (open lake)	1.4
Lake Simcoe	1.5
Lake Michigan	2.7
Lake Muskoka	2.7
Lake Erie (north-western)	12.9
Lake Erie (central)	24.7
Saginaw Bay (L. Huron)	34.6
Lake Erie (south-western)	60.3

The level of primary productivity in Lake Simcoe appears to be similar to that found in Lake Huron and Lake Rosseau, two oligotrophic bodies of water.

It is of interest to note that in 1971, there was no evidence from the productivity data, of a large increase in carbon-uptake rates preceding the phytoplankton scums (see 5.1.14 c). Localized scums were first observed in stagnant bays in late September and by mid-October, some bay areas (e.g. harbour areas in Kempenfelt Bay) contained thick surface scums of the blue-green algae Anabaena. If these scums had been a result of high levels of productivity in late summer, it is reasonable to assume that the productivity sampling in early October would have revealed elevated levels of carbon assimilation.[1]

As described in Section 5.1.14, blue-green algae (e.g. aphanothece, Anabaena) form a significant portion of the free floating algal population. The presence of blue-green species

[1] *An algal scum may take on the appearance of a bloom but is significantly different in that a scum is a concentration of algal cells on the water surface without a significant increase in cell numbers, whereas an algal bloom results from a sharp increase in the number of algal cells in the euphotic zone.*

allows for the possibility of scums developing even though the standing crop of plankton may be generally low. Many blue-greens have prominent "pseudovaculoes" which are believed to have the ability to decrease the cell's density under certain environmental conditions. If this decrease in cell density coincides with calm water conditions, cells will float to the surface and an algal scum can develop.

The lack of historical information on Lake Simcoe does not allow for a good assessment of qualitative or quantitative changes in the phytoplankton population. The fact that lake-wide algal scums were not recorded by O.M.E. prior to 1971 and that scums have been reported during the past four years suggests that the production of blue-green algae has increased. This increase in the standing stock of bluegreens along with meteorological conditions in the past four summers, is the likely cause of these scums.

The dominance of blue-green genera in Lake Simcoe cannot be fully explained. Shapiro (1973) has recently conducted some experimental work which suggests that phytoplankton populations tend to be dominated by blue-greens under high pHlow CO_2 conditions. Since the lake was characterized by a fairly high pH and low concentrations of CO_2 Shapiro's findings may be relevent to conditions found in Lake Simcoe. Further detailed studies of the phytoplankton of Lake Simcoe are required.

While the cause of the blue-green dominance is not clear, the ramifications of this population structure are obvious. The phytoplankton scums which have been recorded annually since 1971 clearly reflect the dominance of blue-greens in the algal populations. It is also possible that the energy flow through the biological system is less than optimal with the dominance of blue-greens and the general sparsity of green algae; there is evidence that phytoplankton predators favour green algae and dislike blue-greens, so that this unfavourable plankton population at the start of the food chain may be limiting production at the upper end of the chain (i.e. fish).

Weed Growths (Periphytic and Macrophytic)

Periphyton (attached algae) growths appear to be an increasing problem in many areas of the lake. Massive growths have been noted for many years in the Shingle Bay area, but, in the past few years, periphytic growths have been noted on previously clean, rocky shorelines on the east and west shores and along Kempenfelt Bay. The filamentous aquatic plant, cladophora, is bright green while growing and slimy to the touch and detracts from the recreational and aesthetic value of a shoreline. In late summer and autumn when the plants detach from the rocks, they may wash up on shore and decompose causing malodourous and unsightly conditions.

It appears that macrophytic weed beds develop in Lake Simcoe wherever there is protection from heavy wave action where organic sediments can accumulate. Since excessive growths materialize only in Shingle Bay and Cook Bay it also appears

that artificial nutrient inputs have perhaps stimulated the productivity of macrophytes to nuisance levels. A more detailed investigation beyond the scope of this study is required if the relationship between local nutrient loadings and aquatic weed protection is to be determined.

Localized weed growths do play an important role in the ecology of the lake by (1) providing suitable spawning and nursery areas for a variety of fish species, (2) providing food and habitat for waterfowl and (3) absorbing nutrients and filtering out solids which would otherwise reach the open lake and increase algal production.

The weed beds in southern Cook Bay are good examples of the three beneficial roles the weeds can play in a lake ecosystem.

7.1.4 Bottom Fauna

The diversity and relative abundance of benthic invertebrates throughout the shallow water area of Lake Simcoe are certainly desirable from the fishery point of view. The southern, eastern and northern parts of the lake can be considered good feeding grounds for those fishes that utilize the bottom fauna in their diet.

In Cook Bay, diversity and balance within the bottom invertebrate community were somewhat impaired as evidenced by the scarcity of caddisflies and mayflies, as well as the apparent absence of fingernail clams in the south end of the bay. This impairment, no doubt, was the result of the heavy organic and sediment loadings to the bay. However, it must be pointed out that the impairment was not severe and that a reasonably suitable variety of organisms was maintained. The abundant growth of macrophytes in both Cook Bay and Shingle Bay probably supported a large invertibrate population. The density of macroinvertibrates in the weeded areas of Cook and Shingle Bays can be expected to be the highest in the lake, although no attempt was made to evalute this population.

The lake-wide mean benthic invertibrate population as measured in 1971 was slightly more than 2000 organisms per square meter. This density is compared in Figure 7.5 to benthic invertibrate populations in the oligiotrophic Muskoka lakes and eutrophic Gravenhurst Bay.

The hypolimnetic benthos of Lake Simcoe (i.e. The invertibrates inhabiting the organic muds in the depth area of the Lake (see Figure 5.17)) is of particular interest. The relatively high density of invertibrates (2000 to 3000 per square metre), the fact that tubificid worms dominate the community and the dominance of <u>Tubifex tubifex</u>, <u>Limnodrilus hoffmeisteri</u>, <u>Procladius</u> and <u>Chironomus</u> <u>s.g.</u> <u>Chironomus</u> are usually typical of a eutrophic lake. Most chemical and biological "yard-sticks" place Lake Simcoe in the Misotrophic-oligotrophic range.

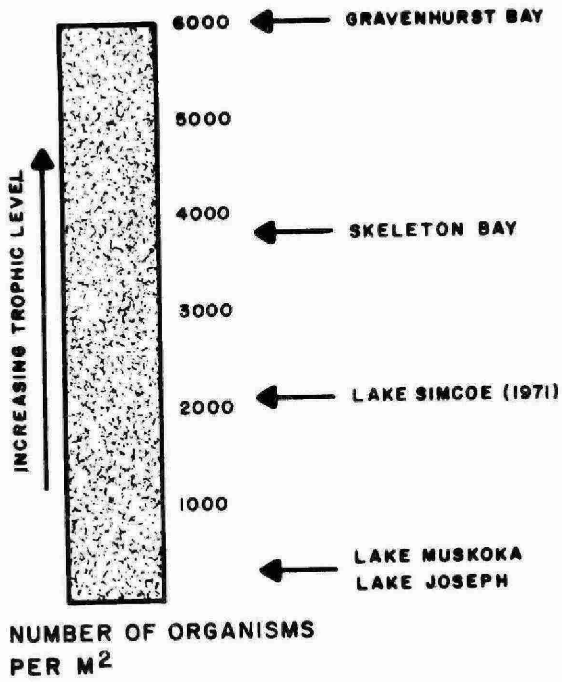


FIG. 7.5 COMPARISON OF BENTHIC ORGANISM POPULATIONS IN THE MUSKOKA LAKES AND LAKE SIMCOE

A recent study of the Muskoka Lakes system (Michalski, Johnson, and Veal, 1973) revealed a close correlation between hypolimnetic benthic community structure and minimum levels of dissolved oxygen in the bottom waters. Other works, including those of Brundin, (1958) have shown the same correlation. It is therefore, assumed that the eutrophic type of hypolimnetic benthic community is primarily a result of the relatively low dissolved oxygen levels (2-3 mg/l) found during the late summer.

It is of interest to note that Rawson (1930) roughly classified the Lake Simcoe hypolimnetic bottom fauna as indicative of eutrophy over 40 years ago even though there was some remaining evidence of oligotrophic species (e.g. odd specimens of Mysis relicta). The 1970 and 1971 sampling revealed that a major change may have occurred since Rawson's study. Possibly the bottom fauna was changing from an oligotrophic to an eutrophic community structure during Rawson's study and has now stabilized as a typical eutrophic benthos dominated by tubificid worms.

A placement of the Lake Simcoe hypolimnetic benthos on the trophic scale can be illustrated by comparing it with the Muskoka Lake benthos. In the Muskoka system, the bottom fauna clearly defined trophic levels ranging from a typically eutrophic structure in Gravenhurst Bay to a typically oligo-

trophic structure in Lake Joseph. The Skeleton Bay section of the Muskoka system would fall between these two extremes and it does support a benthic population which in many respects is similar to that of the deep water areas of Lake Simcoe. Figure 7.6 illustrates some comparison between the benthic communities of the Muskoka Lakes and Lake Simcoe.

In these figures the hypolimnetic benthic community of Lake Simcoe compares closely with eutrophic bays in the Muskoka Lakes. As Lake Simcoe is not eutrophic, this apparent discrepency is most likely attributed to the funnel-shaped lakebed contour and the relatively small hypolimnetic zone (only 20 per cent of the lakes total volume). Much organic material tends to accumulate under the hypolimnetic zone and the bottom is atypical of average lakebed composition. A more detailed discussion of the Lake Simcoe hypolimnetic zone is presented in Section 7.2.

7.1.5 Bacteria

Bacteriological inputs to Lake Simcoe, either by way of streams, municipal or private sewage systems or land drainage, appear to have very little effect on the general bacteriological quality of the lake, both in the surface waters and at depth. However, in the vicinity of many of these inputs, bacteriological levels were higher than open water levels but generally did not exceed the MOE swimming criteria. Local problems in the vicinity of swimming beaches have been documented in the past but it was beyond the scope of this generalized survey to investigate these areas in detail. However, Provincial Agencies through their local offices, maintain a routine surveillance of bacteriological levels in many public swimming areas.

7.2 HYPOLIMNETIC ZONE

The hypolimnetic zone can generally be described as those waters exceeding the 18 meter depth mark. From Figure 2.2 it can be seen that the hypolimnion underlies an area of about 230 square kilometres (90 square miles) in the west-central area of the open lake and most of Kempenfelt Bay. The volume of the hypolimnetic zone of Lake Simcoe is about 24.9 x 10 cubic meters (87.8 x 10^9 cubic feet) or 20 percent of the total lake volume.

As described earlier, the cooler temperature of this zone provides a preferred summer habitat for cold water game fish. Because the zone lies below the depth of light penetration, free floating, rooted or attached aquatic plants do not thrive in the hypolimnion.

Because of the lake bed configuration of Lake Simcoe which can be described as resembling a funnel, suspended solid materials (tributary and STP inputs, dead algae and aquatic weeds, leaves, etc.) are drawn by gravity and currents to this zone of low energy where they settle to the bottom. It is interesting to note that the area of lake bottom classified as

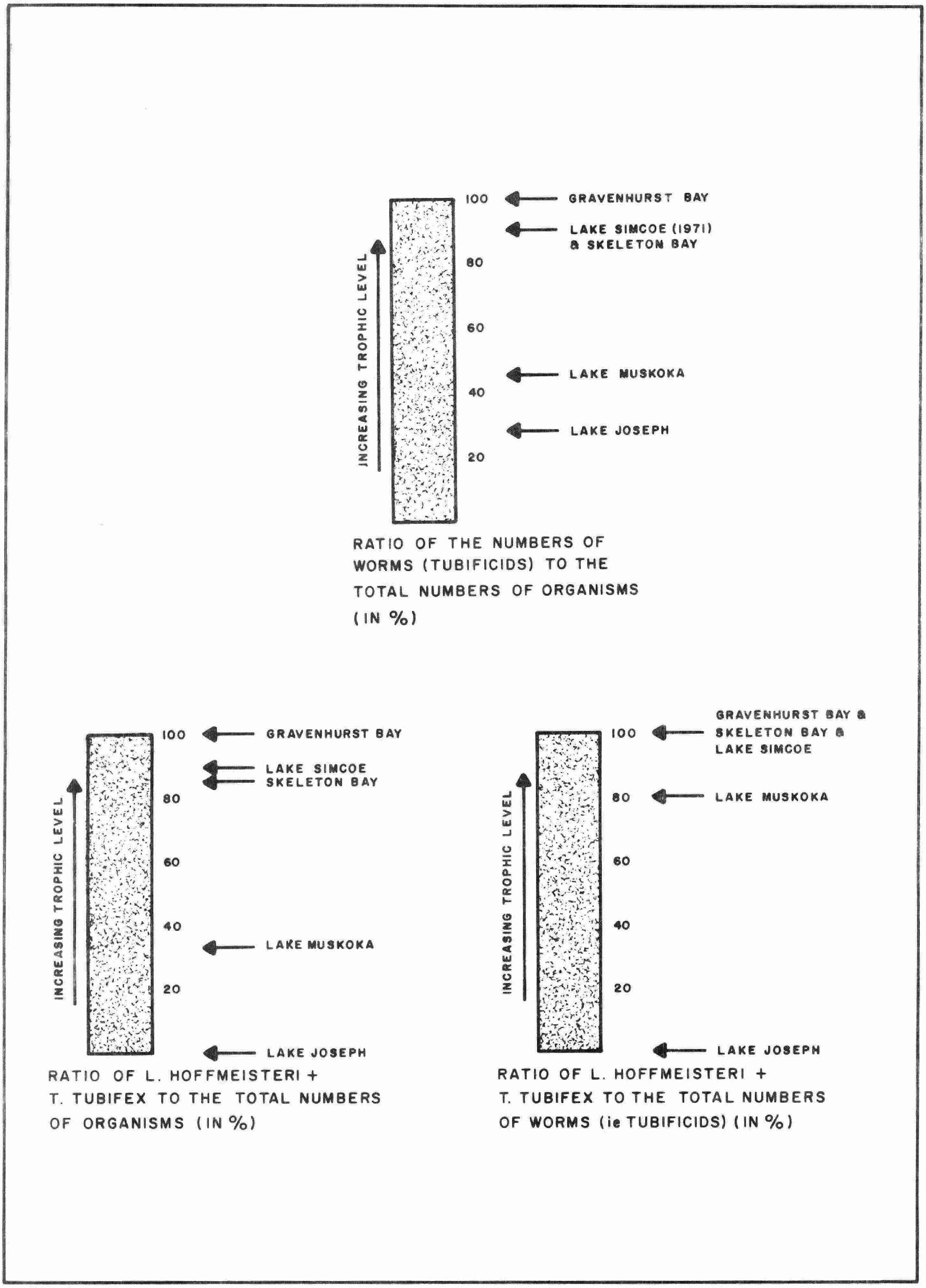


FIG. 7.6 COMPARISON OF BENTHIC COMMUNITIES IN MUSKOKA LAKES AND THE DEEP WATER AREAS OF LAKE SIMCOE

"mud" generally coincides with the area underlying waters deeper than 18 meters (Fig. 5.17).

Water quality in the hypolimnetic zone can be generally described as good. Nutrients, solids, conductivity, hardness, bacterial levels, etc. are consistent with levels in the surface waters. During the winter and spring months DO and temperature are generally uniform throughout the vertical profile (see Section 5.1). During summer and fall stratification, however, water temperatures are 10-12 °C cooler than surface waters and dissolved oxygen concentrations are substantially lower. In the following section, the causes of oxygen depletion in the hypolimnetic zone are discussed.

7.2.1 Lakebed Composition

As outlined in Section 5.4.2 the lakebed of Lake Simcoe consists primarily of sand and rock in the shallow and exposed areas of the lake and mud in the deeper and sheltered areas of the lake. These findings along with the findings related to suspended solids outlined previously in Section 5.5 (Water Clarity), substantiate the premise that, in the open lake, wind-induced currents and gravity are transporting settleable solids to the relatively small hypolmnetic zone where settling occurs.

The accumulation of organic sediment in the lake is attributable to several sources, principally, inputs from tributary streams, sewage treatment plants, dead aquatic weeds and phytoplankton (which grows in the euphotic zone throughout the 725 square kilometers surface area, but accumulates primarily in the sediments underlying the hypolimnetic zone). The sedimentation rates and the magnitude of each source of organic sediments were not measured directly, but it is estimated that at least 50 percent of the settling organic material is dead aquatic plant and algae produced in Lake Simcoe.

7.2.2 Oxygen Depletion in the Hypolimnion

As described in earlier sections of this report, vertical stratification occurs each year in those areas of Lake Simcoe exceeding 18 meters (60 feet) in depth. As the summer proceeds, the dissolved oxygen concentration in the hypolimnetic zone is steadily reduced from 100 percent saturation following spring turnover to about 25 percent saturation before fall turnover.

In an effort to define the cause of this oxygen depletion and predict hypolimnetic dissolved oxygen levels under different water temperature and loading conditions, studies to determine the oxygen demand rate of lake sediments were carried out and models of the vertical mixing phenomenon and the dissolved oxygen balance of Lake Simcoe were developed.

7.2.3 Benthic Oxygen Demand

As pointed out in Section 5.4.2 (b) oxygen uptake rates averaged about 0.65 gms O_2/m^2/day (1.4×10^5 lbs 0 /ft^2 /day) in the deeper areas of the lake and 0.32 O_2/m^2/day in the Cook Bay.

7.2.4 Dissolved Oxygen Balance

A mathematical model of the dissolved oxygen regime of Lake Simcoe was developed to confirm the causes of oxygen depletion in the hypolimnetic zone and predict quality changes with the implementation of remedial measures. Before the oxygen balance equation could be established a means of measuring the mixing of water between the vertically stratified zones of the lake had to be developed. Detailed water temperature data from several key stations in the deeper areas of the lake were evaluated and vertical water columns as illustrated in Figure 7.7 were constructed. Heat transfer between zones (i.e. epilimnion to metalimnion) was assumed to occur primarily by mechanical mixing at the zone interface by the application of external energy sources (e.g. wind force). Heat gain and loss was assumed to occur primarily at the lake surface, i.e. heat transfer at the lake bed was not significant. The mass transfer (as shown by heat transfer) between zones was then determined using an equation as follows:

$$K_V = \frac{X}{V_3} = \frac{T_3 - T_{0\,3}}{\left[\dfrac{t \left[1+\dfrac{V_2}{V_3}\right] (T_2 - T_{0\,2})}{L_n \left[\dfrac{T_2}{T_{0\,2}}\right]} - \dfrac{V_2(T_2+T_{0\,2}) + V_3(T_3+T_{0\,3})}{2V_3} \right]}$$

where:

X = the volume of the water exchanged between zones per day (ft^3/day).

V_2 = the volume of a column in zone 2 of one square foot horizontal area (ft^3).

V_3 = the volume of a column in zone 3 of one square foot horizontal area (ft^3).

T_2 = the average temperature of the metalimnetic zone at any time t (^{0}C).

$T_{0\,2}$ = the average temperature of the metalimnetic zone at time t = 0 (^{0}C).

T_3 = the average temperature of the hypolimnetic zone at any time t (^{0}C).

$T_{0\,3}$ = the average temperature of the hypolimnetic zone at t = (^{0}C).

t = time interval (days).

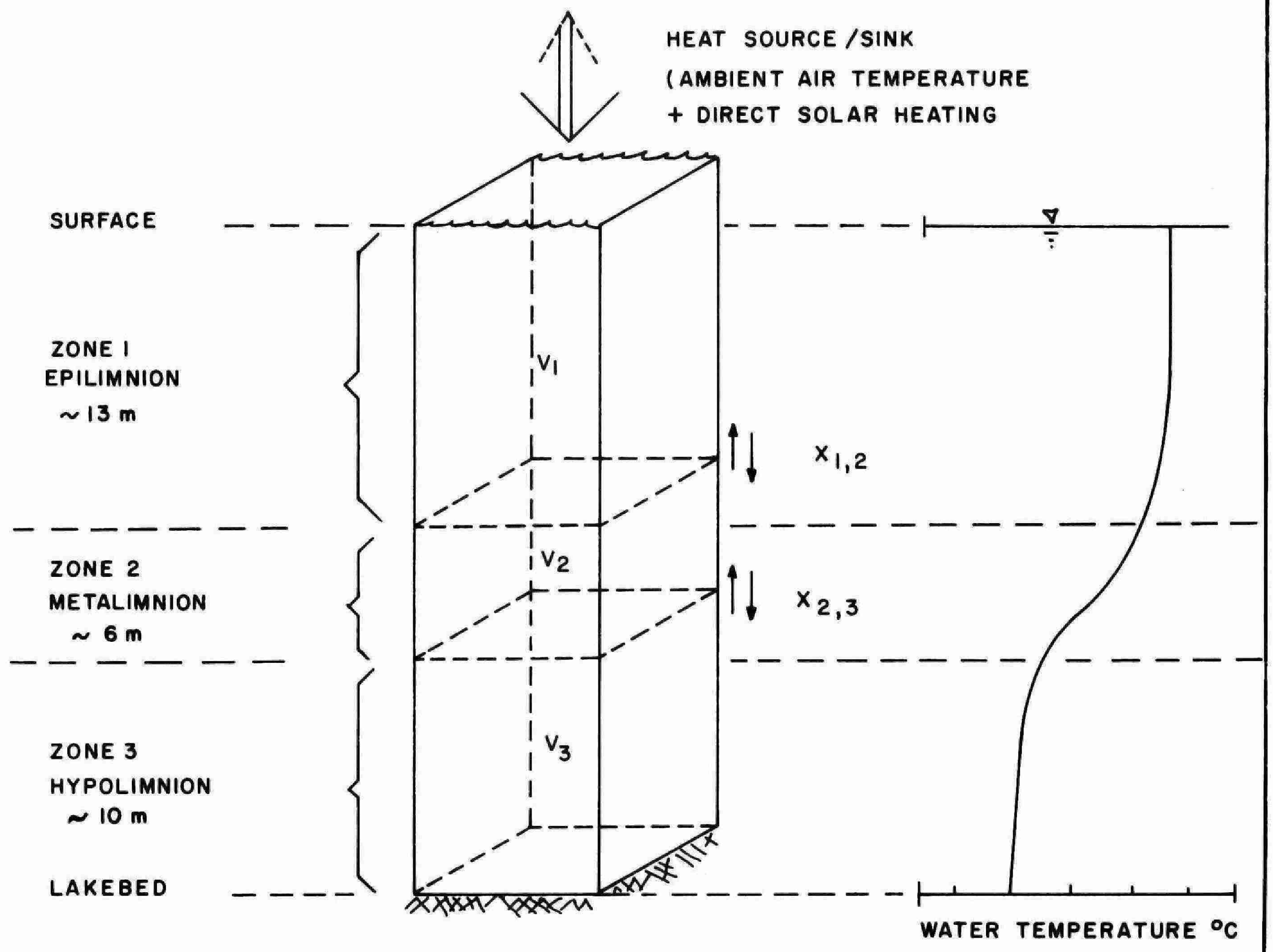


FIG. 7.7 WATER COLUMN – DEFINITION OF ZONES

The rate of interzone mixing (X/V) thus established was then employed in the oxygen balance equation (used in the determination of K_V) to determine the amount of oxygen transfer between zones. This equation, reduced to its simplest terms is the sum of oxygen sources (atmospheric reaeration, photosynthetic production, etc.) minus the dissolved oxygen sinks (benthic oxygen demand, suspended and dissolved biochemical demand, aquatic plant and algae respiration, etc.) and was used in the following form:

$$D_3 = D_{03} \quad e^{-Kvt} + \frac{K_V \; D_{02}}{K_V - K_{02}} \left(e^{-K_{02}t} - e^{-K_V t}\right)$$

$$+ \frac{lo + So}{K_V + K_T} \left(e^{-K_V t} - e^{K_r t}\right)$$

where:

D_3 = the resultant dissolved oxygen level in the hypolimnetic zone (mg/l).

D_{03} = the initial dissolved oxygen level in the hypolimnetic zone (mg/l).

2,3 = the zone designation (2 is metalimnetic zone, 3 is the hypolimnetic zone).

K_V = the mixing coefficient (rate of change of volume between zones per day as established in the mixing model).

t = the time from initial formation of the thermocline (days).

K_{02} = the rate of change per day of dissolved oxygen in the metalimnetic zone.

K_T = the rate of change of the temperature coefficient per day - $\frac{Ln\ 1.04\ T}{t}$.

lo = the suspended and dissolved biochemical oxygen demand 9mg/l per day).

So = the benthic oxygen demand (mg/l of 0_2 per day).

The oxygen balance equation was developed using data collected during the 1971 survey period and verified using 1970 and 1972 dissolved oxygen and temperature information.

7.2.5 Application of the Dissolved Oxygen Model

The oxygen model illustrates that benthic oxygen demand, suspended and dissolved BOD_5 maximum hypolimnetic temperatures, and duration of the thermocline all may significantly affect the hypolimnetic dissolved oxygen level. Under current conditions of BOD_5 loading and benthic demand during an average summer, the hypolimnetic waters heat to about 10°C and the dissolved oxygen level drops to about 3 mg/l in September (Figure 7.8a). Examples to illustrate the effects of water temperature and oxygen demanding materials on dissolved oxygen were developed from the model (Figure 7.8b and Figure 7.8c).

In Figure 7.8b, water temperatures were higher and dissolved oxygen levels were lower than average as a result of late thermocline formation. Benthic oxygen demand and BOD_5 levels, as measured during 1971 and 1973 survey period, were employed. Dissolved oxygen levels were calculated for each month that the thermocline existed (mid-July through October). The resultant dissolved oxygen profile shows that by mid-September the hypolimnetic dissolved oxygen concentration had been reduced to about 2 mg/l and if stratification continued into October, levels of less than 1 mg/l could be expected.

In Figure 7.8c, average spring and summer heating conditions were employed and the oxygen demanding loading was reduced by 50 percent. The resultant dissolved oxygen profile shows a major improvement in hypolimnetic conditions. Dissolved oxygen did not fall significantly below 5 mg/l even when the stratification period was extended into October. While the examples presented in Figure 7.8b and 7.8c are hypothetical they dramatically illustrate the effects of temperature and oxygen demanding materials on hypolimnetic dissolved oxygen levels.

7.3 TRIBUTARY STREAMS

Significant water quality impairment was found downstream from the municipal discharges from the towns of Aurora, Newmarket and Uxbridge (see Section 5.3). Low dissolved oxygen levels were measured in the Beaverton River in the vicinity of Sunderland downstream to the Village of Cannington; these low levels were likely the result of the oxygen demand of the decaying aquatic plants and low reaeration capabilities of the stream in this area rather than municipal discharges to the stream.

Water quality problems related to individual wastewater discharge within the tributaries to Lake Simcoe have been (or will be) dealt with as they are identified.

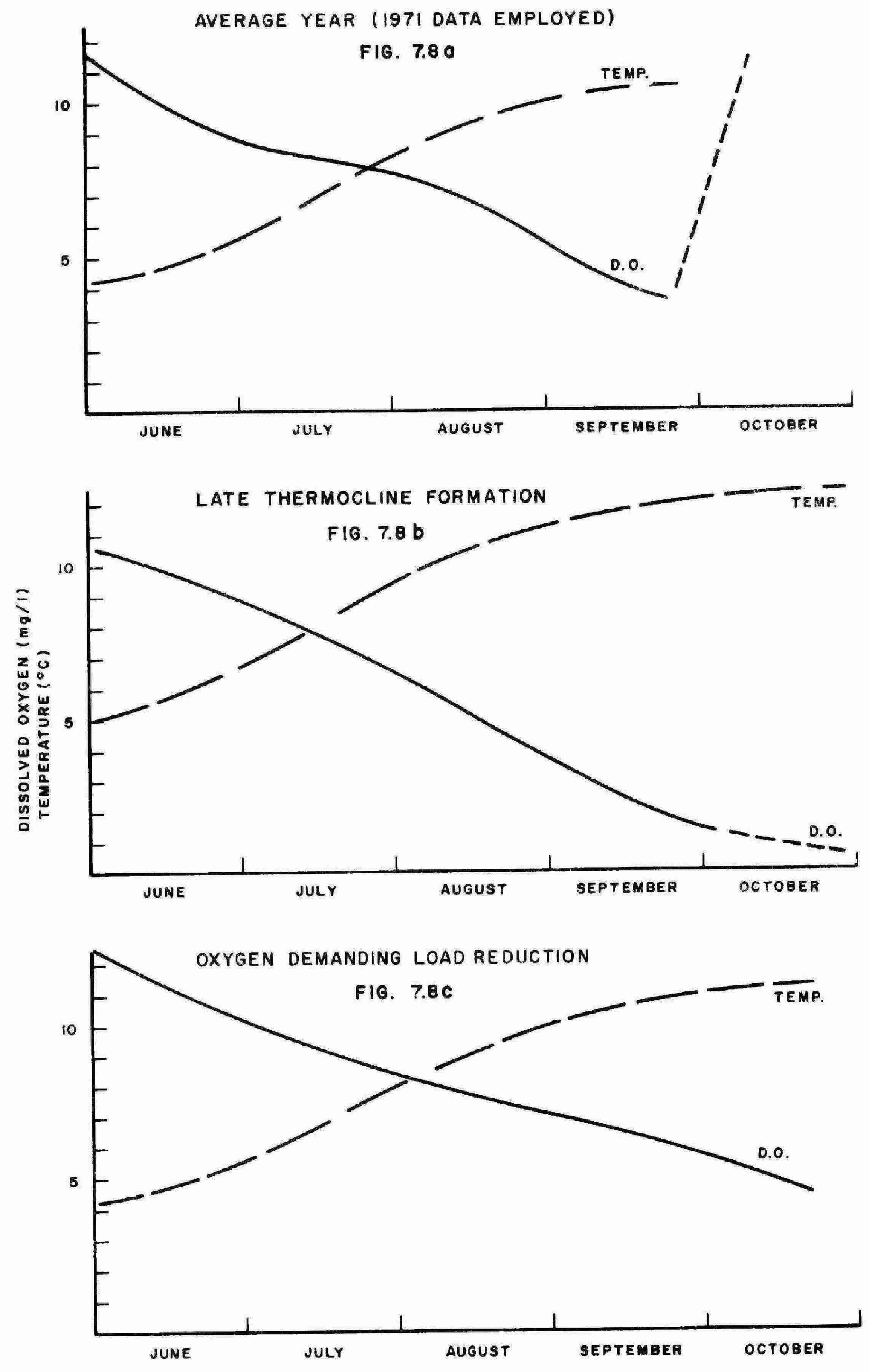


FIG. 7.8 HYPOLIMNETIC DISSOLVED OXYGEN AND TEMP. CONDITIONS

CHAPTER 8 - THE FISHERIES

The Lake Simcoe Fishery supports angling for about 15 percent of the province's sport fishermen. This is second only to Georgian Bay. One-third of the anglers from the Toronto area fish in Lake Simcoe waters (MNR). Lake Simcoe and Lake Couchiching together provide over 900,000 angler days per year (CORTS). In recent years however, changing trends have been observed in the quality of the resource and problems are evident with certain species. Due to the number and complexity of factors which can stress an aquatic ecosystem, a comprehensive evaluation of their impact is difficult.

In recognition of the value of Lake Simcoe and its fishery, the Lake Simcoe Fisheries Assessment Unit was established at Sibbald Point Park in 1964 to obtain a better understanding of the lake. H. R. MacCrimmon and E. Skobe published an important paper on the lake and its resources in 1970.

The primary objective of this chapter is to update information and permit a better understanding of the fishery of Lake Simcoe.

8.1 THE SUMMER FISHERY

Lake Simcoe's summer sport fishery relies upon a variety of species. Of particular importance are lake trout, walleye, smallmouth bass, northern pike and yellow perch. The fish populations are influenced by anglers and natural population fluctuations. To maintain records on the relative size and vital statistics of these fish stocks a permanent monitoring system has been established using index trap net stations and a creel census.

8.1.1 Index Netting

By netting at index stations (Figure 8.1) during similar time periods annually, data were provided on species composition, relative abundance, age structures and growth rates. Tagging walleye and smallmouth bass provides information on movement and exploitation rates for these species.

Data obtained from the individual netting stations were expressed in terms of catch per unit of effort (C.U.E.). For trap nets C.U.E. was calculated as the number of each species caught per net day. Total catches and the C.U.E. by species for the period 1970-1974 are presented in Table 8.1.

8.1.2 Summer Creel Census

The creel census, which was based on a prescheduled sampling of anglers, enabled relative estimates of fishing pressure and the calculation of C.U.E. for each species caught. The angler C.U.E. was calculated as the number of fish caught per angler hour. The lake was divided into four census areas: the open lake, the Atherley area, south shore and Cook Bay (Figure 8.2). Census data were collected between May 1st and September 15th. Each census area was covered completely once

TABLE 8.1 RECORDED CATCH AND C.U.E. AT LAKE SIMCOE INDEX NET LOCATIONS, 1970 - 1974

Index Netting Site	Year	Net Day	Smallmth.Bass Tot.	CUE	Walleye Tot.	CUE	Yellow Perch Tot.	CUE	White Sucker Tot.	CUE	Brn.Bullhead Tot.	CUE	N. Pike Tot.	CUE	Pumpkinseed Tot.	CUE	Rock Bass Tot.	CUE
Mara	70	8	12	1.5	92	11.5	180	22.5	79	9.8	3	0.3	0	0	0	0	0	0
	71	15	139	9.3	370	21.4	116	11.1	196	13.1	18	1.2	0	0	0	0	0	0
	72	23	440	19.1	376	16.3	394	17.1	380	16.5	111	4.8	7	.3	6	.3	25	1.1
	73	34	144	4.2	344	10.1	191	5.6	873	11.0	100	2.9	1	.3	8	.24	11	.3
	74	49	511	10.4	217	4.4	131	2.7	85	1.7	170	3.5	11	.2	14	.3	77	1.6
	70	73	591	7.9	549	7.5	753	10.3	302	4.1	335	4.5	5	.2	180	2.4	40	.5
Port	71	40	326	8.1	248	6.2	354	8.8	110	2.7	364	9.1	5	.1	123	3.1	39	.9
Bolster	72	25	200	8.0	183	7.3	644	25.7	245	9.8	107	4.3	0	0	20	.8	37	1.5
	73	41	228	5.6	232	5.7	229	5.6	73	1.8	39	1.0	1	.02	16	.4	25	.6
	74	55	306	5.6	142	2.6	583	10.6	68	1.2	13	.2	10	1.8	94	1.7	66	1.2
Cook Bay	66	26	18	.6	46	1.7	225	8.6	31	1.1	925	35.5	186	7.1	67	2.5	32	1.2
	67	44	214	4.8	79	1.7	1216	27.6	170	3.6	2052	46.6	273	6.2	1697	38.5	204	4.6
	72	6	18	3.0	7	1.2	2	.3	5	.8	7	1.2	4	.7	160	26.7	6	1.0
Georgina	67	22	79	3.5	77	3.5	128	5.8	107	4.8	271	12.3	25	1.1	41	1.8	30	1.3
Basin	68	12	21	1.7	26	2.1	99	8.2	136	11.3	187	15.5	23	1.9	67	5.5	31	2.5
	69	103	115	1.1	231	2.4	384	3.7	148	1.4	408	4.0	77	.7	91	.9	154	1.5
	70	27	19	.7	91	3.3	56	2.1	53	1.9	208	1.7	21	.7	15	.5	5	.1
	71	19	30	1.6	17	.9	29	1.5	5	0.3	5	.3	2	.2	30	1.6	1	.1
	72	35	105	3.0	34	1.0	298	8.5	135	3.9	361	10.3	18	.5	179	5.1	62	1.8
	73	30	12	.4	39	1.3	33	1.1	57	1.9	257	7.6	4	.8	128	4.3	23	.8
	74	20	83	2.5	41	1.4	12	.4	21	.7	37	1.3	34	3.1	37	1.3	50	1.7
North	73	24	27	1.1	12	.5	39	1.6	28	1.2	9	.4	0	0	36	1.5	6	.3
Georgina	74	10	8	.8	0	0	31	3.1	11	1.1	2	.2	1	.1	9	.9	2	.2

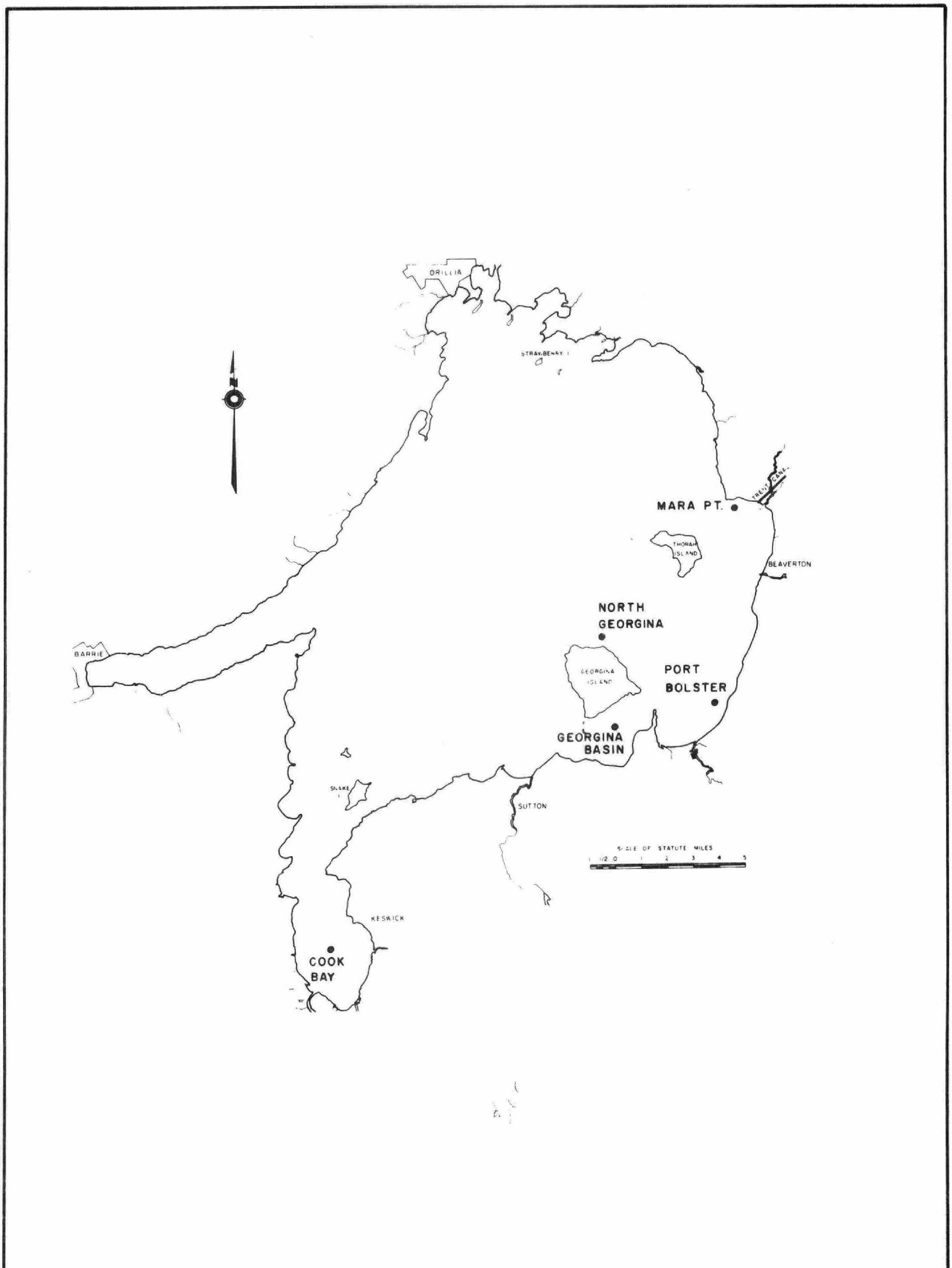


FIG. 8.1 LAKE SIMCOE INDEX TRAP NET STATIONS

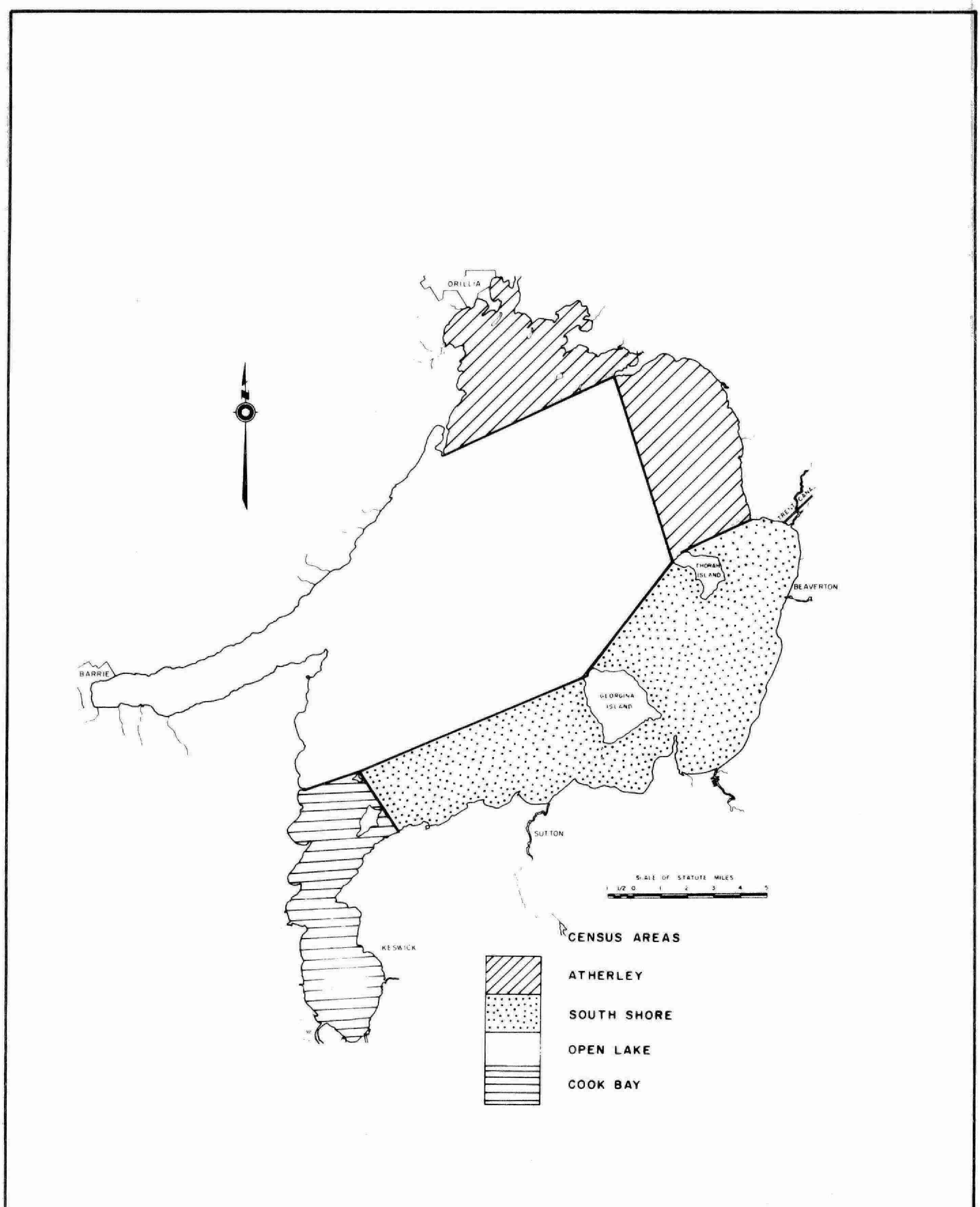


FIG. 8.2 LAKE SIMCOE SUMMER CREEL CENSUS AREAS

every five days. Creel census data for 1968 - 1974 are summarized in Table 8.2.

Undoubtedly, a creel census is not in itself an absolute criterion for determining the well being of fish populations, but as part of a continuous data series, census data provides an index to population trends and when compared with winter creel results and biological sampling, broad inferences can be drawn on the status of various species. An example of this is a lack of older age classes and an increase in growth rate resulting from over exploitation.

8.1.3 Species Sought

Lake trout *Salvelinus namaycush*, smallmouth bass *Micropterus dolomieui*, walleye *Stizostedion vitreum*, yellow perch *Perca flavescens* and northern pike *Esox lucius* are the species most commonly sought in the summer fishery.

Brown bullheads *Ictalurus nebulosus* , muskellunge *Esox masquinongy*, pumpkinseeds *Lepomis gibbosus*, and white-fish *Coregonus Clupeaformis* also contribute to summer creels.

(a) Lake Trout

Lake trout are sought intensively throughout the summer months in the deepwater areas of the lake. Although lake trout have not been abundant through the years 1968 - 1974, their availability has remained relatively constant and they do sustain an important fishery. Historical evidence suggests that lake trout are no longer as numerous in the lake as in the past. Substantial declines of spawning lake trout occurred in the 1960's. The exact reasons for the decline are not known although it appears that ecological changes may have adversely affected natural reproduction. Salmonids in particular have been described as ecologically sensitive taxa which act as reliable indicators of stressfull conditions (Loftus and Regier 1972).

Yearling and two year old trout are planted annually to supplement natural stocks (Table 8.3). Stocked lake trout now compose 15 to 20 per cent of the trout harvested.

(b) Smallmouth Bass

Angler catches of smallmouth bass have increased steadily over the past few years. This would suggest gradually increasing abundance levels or possibly more successful exploitation of the species by fishermen; increased catches of bass at index netting sites supports the former view. Assessing changes in the expertise of fishermen in catching bass would be most difficult.

Bass make a substantial contribution to the anglers' creel throughout the summer. Angler success has improved from an average of 27.9 man hours of angling effort per fish (C.U.E. - .04) in 1968 to 7.4 hours (C.U.E. - .13) in 1974. The trap net index C.U.E. for smallmouth bass at Mara Point has

TABLE 8.2 CREEL CENSUS SUMMARY, SUMMERS OF 1968 - 1974 (ANGLER CATCH, C.U.E., AND MAN HRS/FISH CAUGHT)

Year	Area	Lake Trout			Northern Pike			Yellow Perch			Smallmth. Bass			Whitefish			Total All Species		
		No.	CUE	Hr/Fsh	No.	CUE	Hr/Fsh	No.	CUE	Hr/Fsh	No.	CUE	Hr/Fsh	No.	CUE	Hr/Fsh	No.	CUE	Hr/Fsh
1968	Open Lake	59	.06	16.0	0	0	--	8	.01	118.2	0	0	--	271	.29	3.5	338	.36	2.8
	South Shore	0	0	--	0	0	--	281	.25	3.9	112	.10	10.0	155	.14	7.2	548	.49	2.0
	Cook Bay	0	0	--	39	.07	14.6	23	.04	22.8	9	.02	58.3	0	0	--	71	.14	7.4
	Atherley	2	0	392.0	4	.01	196.0	1859	2.37	0.4	0	0	--	29	.04	27.0	1894	2.42	0.4
	Total	61	.02	55.3	43	.01	78.5	2171	.64	1.6	121	.04	27.9	455	.13	7.4	2851	.84	1.2
1969	Open Lake	28	.03	34.8	0	0	--	14	.01	69.7	14	.01	69.7	282	.29	3.5	338	.35	2.9
	South Shore	1	0	840.0	16	.02	52.5	292	.35	2.9	120	.14	7.0	179	.21	4.7	608	.72	1.4
	Cook Bay	0	0	--	54	.06	15.7	59	.07	14.4	0	0	--	0	0	--	113	.13	7.5
	Atherley	0	0	--	1	0	705.0	1775	2.52	0.4	0	0	--	53	.08	13.3	1829	2.59	0.4
	Total	29	.01	116.2	71	.02	47.4	2140	.64	1.6	134	.04	25.1	514	.15	6.6	2888	.86	1.2
1970	Open Lake	5	.02	64.4	0	0	--	66	.20	4.9	3	.01	107.3	14	.04	23.0	88	.27	3.7
	South Shore	0	0	--	4	.01	194.0	290	.37	2.7	233	.30	6.7	16	.02	48.5	543	.70	1.4
	Cook Bay	0	0	--	25	.03	32.2	143	.18	5.6	6	.01	134.3	0	0	--	174	.22	4.6
	Atherley	0	0	--	11	.01	118.1	571	.44	2.3	143	.11	9.1	1	.01	1300.0	726	.56	1.8
	Total	5	0	638.8	40	.01	79.8	1070	.34	3.0	385	.12	8.3	31	.01	103.0	1531	.48	2.1
1971	Open Lake	14	.07	14.1	0	0	--	27	.14	7.3	1	.01	198.0	9	.05	22.0	51	.26	3.9
	South Shore	0	0	--	0	0	--	736	.99	1.0	175	.23	4.3	24	.03	31.1	935	1.25	0.8
	Cook Bay	0	0	--	48	.03	32.8	382	.24	4.1	28	.02	56.4	0	0	--	458	.29	3.4
	Atherley	0	0	--	2	0	702.5	1869	1.33	0.8	58	.04	24.2	5	0	281.0	1934	1.23	0.7
	Total	14	.01	273.3	50	.01	78.5	3014	.77	1.3	262	.07	15.0	38	.01	103.3	3378	.86	1.2
1972	Open Lake	44	.06	17.1	6	.01	125.6	156	.21	4.8	0	0	--	51	.07	14.8	227	.34	3.3
	South Shore	0	0	--	0	0	--	335	.32	3.1	164	.16	6.3	39	.04	26.5	538	.52	1.9
	Cook Bay	0	0	--	84	.03	31.3	569	.22	4.6	175	.07	15.1	2	0	1318.0	830	.31	3.2
	Atherley	12	.01	141.5	7	0	242.7	1577	.93	1.1	215	.13	7.9	28	.02	60.7	1839	1.08	0.9
	Total	56	.01	109.3	97	.01	63.1	2637	.43	2.3	554	.10	11.0	120	.02	51.0	3464	.60	1.8
1973	Open Lake	7	.02	64.4	0	0	--	32	.07	14.1	20	.04	22.6	47	.10	9.6	106	.24	4.3
	South Shore	0	0	--	0	0	--	71	.16	6.4	160	.35	2.9	0	0	--	231	.51	2.0
	Cook Bay	0	0	--	27	.02	60.3	177	.11	9.2	100	.06	16.3	0	0	--	304	.19	5.4
	Atherley	2	0	576.0	4	0	288.0	474	.41	2.4	163	.14	7.1	0	0	--	643	.56	1.8
	Total	9	0	409.5	31	.01	118.9	754	.21	4.9	443	.12	8.3	47	.01	78.4	1284	.35	2.9
1974	Open Lake	27	.05	19.6	1	0	530.0	417	.79	1.3	32	.06	16.6	5	.01	106.0	482	.91	1.1
	South Shore	2	0	589.5	4	0	294.7	444	.38	2.7	284	.24	4.2	20	.02	4.2	754	.62	1.6
	Cook Bay	0	0	--	54	.06	17.8	134	.14	7.2	16	.02	59.9	0	0	--	204	.21	4.7
	Atherley	4	0	449.0	12	.01	149.7	1949	1.09	0.9	269	.15	6.7	0	0	--	2234	1.24	0.8
	Total	33	.01	135.2	71	.02	62.9	2944	.66	1.5	601	.13	7.4	25	.01	178.6	3674	.82	1.2

TABLE 8.3

LAKE TROUT STOCKING IN LAKE SIMCOE
1964 - 1974

Year	Number of Fish	Age of Fish When Planted
1964	25,000	Yearling
1965	40,000	Fingerling
	10,000	Yearling
1966	20,000	Yearling
	227,500	Fingerling
1967	65,000	Fingerling
1968	9,000	Yearling
1969	1,400	Two Year Olds
	20,000	Yearling
1970	40,400	Fingerling
	60,050	Yearling
1971	2,580	Yearling
1972	15,000	Yearling
	2,000	Two Year Olds
1973	10,000	Two Year Olds
	30,000	Yearling
1974	31,000	Yearling
	5,900	Two Year Olds
	1,079,180	

increased from 1.5 fish per net day in 1970 to a peak of 19.1 in 1972 and has since dropped to 10.4 in 1974. The index C.U.E. for trap nets for the Port Bolster area has remained near 8.0 in 1971 and 1972 and has declined to 5.6 in 1973 and 1974. In the Georgina Basin, bass index levels have changed little between 1967 and 1974.

The south shore area accounts for 50 per cent of the bass caught in the lake, followed by the Atherley area at 34 per cent, Cook Bay at 13 per cent and the open lake at 3 per cent. All percentage calculations are for the period 1968 - 1974, inclusive.

Age composition analysis of smallmouth bass (Figure 8.3) suggests a healthy population structure with good recruitment of young fish into the spawning population. A large percentage of the bass are aged two and three with the greatest decrease in numbers between age three and four. Possibly this decrease indicates an increased susceptibility to angling at this size and age. The growth curve for smallmouth bass in Lake Simcoe is given in Figure 8.4.

Available data from index netting sites and angler creels indicate that the Lake Simcoe bass population is continuing to thrive. Typically the bass are of good size and excellent quality.

(c) Walleye

Lake Simcoe has several walleye spawning runs in the spring, the most spectacular run occurring in the Talbot River on the east shore of the lake. Following the opening of the season in the spring, walleye are readily caught but fishing becomes mediocre during the summer. Over the season few walleye are caught as evidenced by a 2 per cent tag return of almost 3,500 walleye tagged since 1968.

In the trap net series the C.U.E. for walleye averages 16.5 in 1972 at Mara Point and has remained fairly constant near 7.3 at Port Bolster. Declines occurred in 1974 at both Mara Point and Port Bolster to 4.4 and 2.6 respectively. Netting delays caused by inclement weather may have been partially responsible for the decline. In the spring, walleye disperse rapidly after leaving the rivers.

Age composition analysis of walleye (Figure 8.5) indicates a healthy population structure; there is strong recruitment of young fish and steadily decreasing numbers in succeeding age groups. This is thought to reflect their relatively unexploited existence. The growth curve (Figure 8.6) compares favourably with walleye in other waters.

(d) Other Species

Angler C.U.E. for yellow perch, although it has fluctuated, has not changed drastically in the 1968 to 1974 period. The summer angler C.U.E. for perch is an anomaly in that other signs point to a rapidly increasing perch population. It is

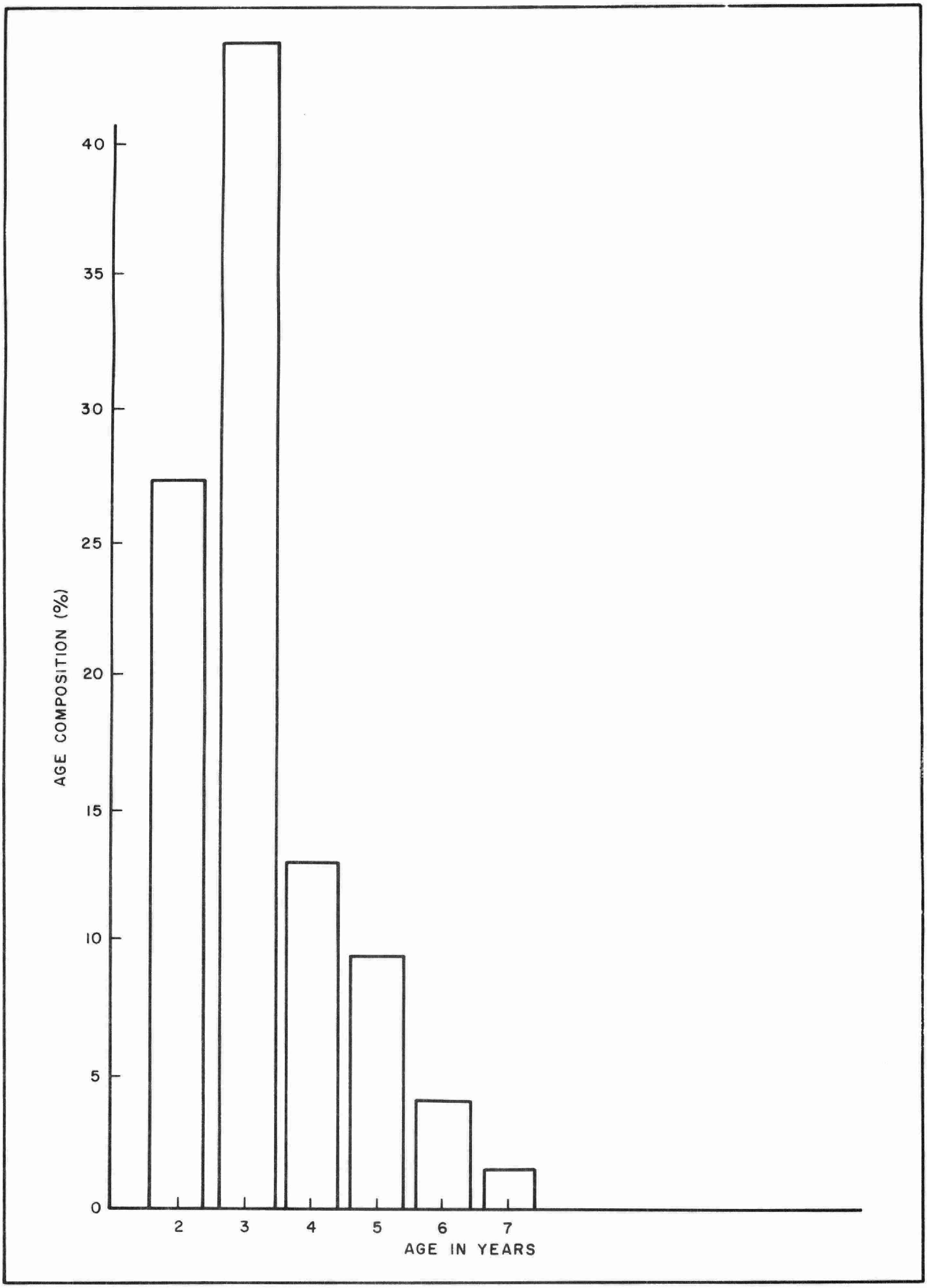


FIG. 8.3 AGE COMPOSITION OF SMALLMOUTH BASS CAPTURED AT LAKE SIMCOE INDEX TRAP NET STATIONS (1973)

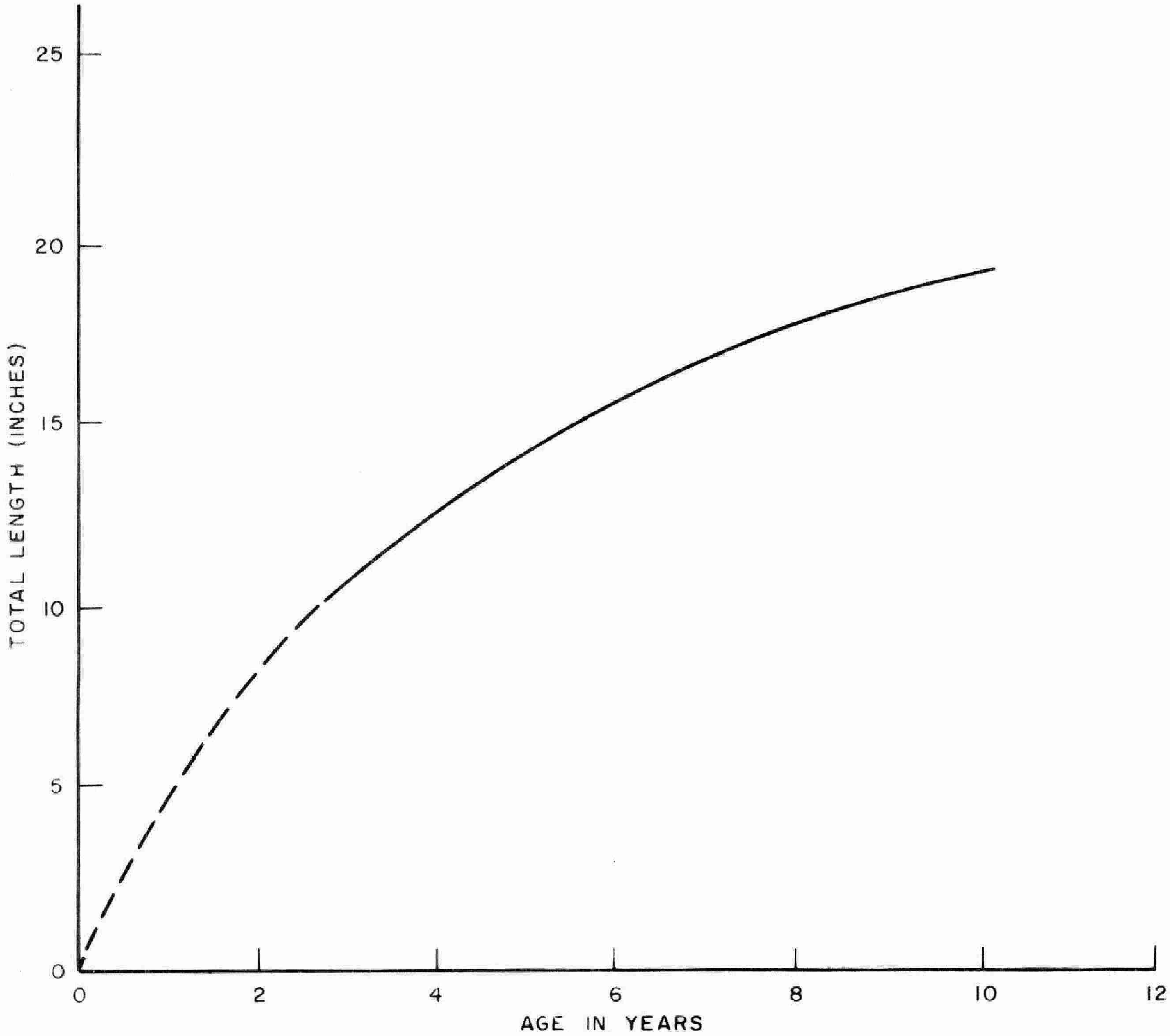


FIG. 8.4 GROWTH CURVE OF SMALLMOUTH BASS CAPTURED AT LAKE SIMCOE INDEX TRAP NET STATIONS (1972)

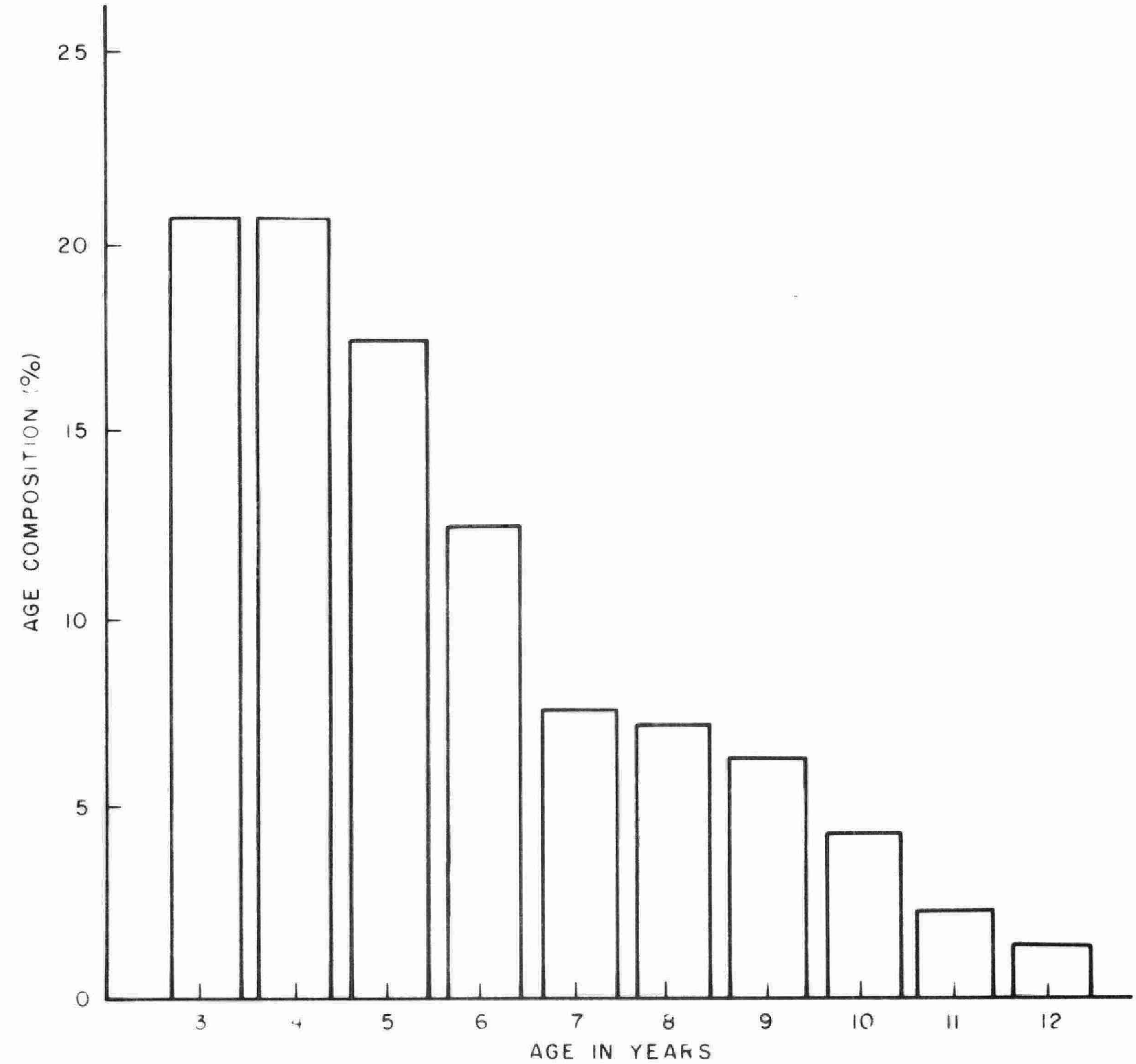


FIG. 8.5 AGE COMPOSITION OF WALLEYE CAPTURED AT LAKE SIMCOE INDEX TRAP NET STATIONS (1972)

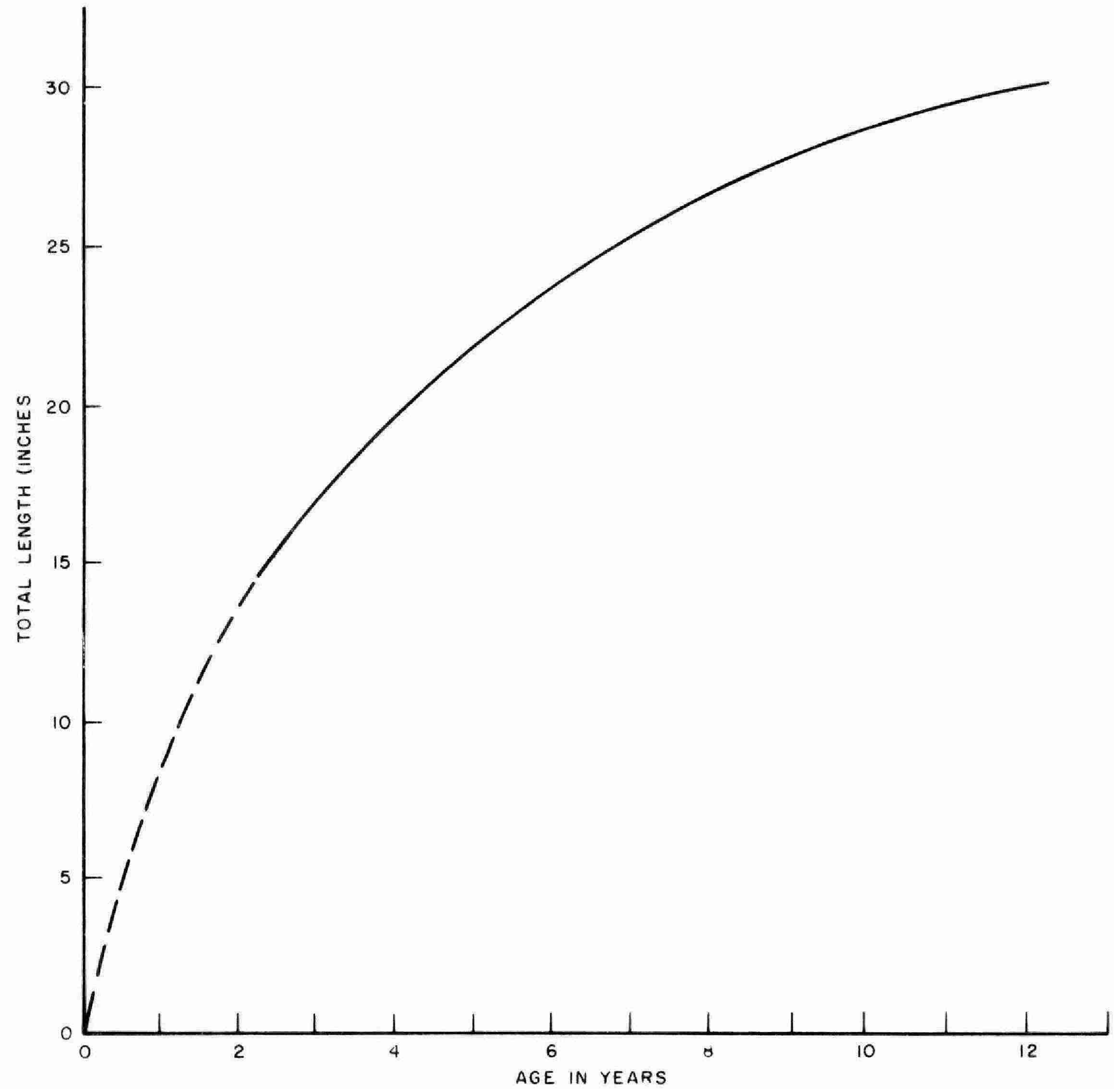


FIG. 8.6 GROWTH CURVE OF WALLEYE CAPTURED AT LAKE SIMCOE INDEX TRAP NET STATIONS (1972)

possible that the index trap net data does not give a true indication of actual perch increases in the lake due to its selectivity for larger perch. Large numbers of small yellow perch are evident and it is thought that population pressures have resulted in slow growth. This is discussed more completely in Section 8.2 (The Winter Fishery).

Increasing index C.U.E. values for whitesuckers is evident for most stations although there is a substantial drop in 1974 index catches. Index catch levels for pumpkinseeds and brown bullheads have remained steady. A low but stable angler C.U.E. for northern pike parallels pike availability as expressed by trap net catches. Of particular interest is the summer angling for whitefish. Between 1968 and 1971, the same time that decreases in the winter catch of whitefish occurred, the angler effort for whitefish increased from 7.4 man hours per fish (C.U.E. 0.13) to 100.3 man hours per fish (C.U.E. 0.01). In 1974 on the average it required 178.6 man hours to catch a whitefish.

8.1.4 Summary

Present data indicates that the warm water fishery is stable and being subjected to moderately intense exploitation rates. Preliminary information suggest that population stresses are evident in the whitefish populations.

8.2 THE WINTER FISHERY

The sport of fishing through the ice has grown in popularity on Lake Simcoe over the years. The first fish huts began to appear in the 1900's. By 1950 there were about 800 huts on the lake each winter and in the 1960's more than 4,000 huts were recorded. Presently 3,600 huts have been counted at the peak of the season. Many people own their own fish huts but thirty-seven commercial hut operators around the lake have a rental capacity for 2,190 anglers at one time. An estimated 65,000 to 70,000 anglers participate in winter fishing on Lake Simcoe each year. Many winter anglers fish without a shelter. These open-ice fishermen account for approximately 14 per cent of the winter anglers. With the rise in popularity of snow machines in the 1970's, there has been a gradual increase in the number of open-ice fishermen.

8.2.1 Species Sought

Whitefish *Coregonus clupeaforuis* , and lake trout *Salvelinus namaycush* are the two species preferred in the winter fishery. Other species commonly taken through the ice include herring *Coregonus artedi* yellow perch *Perca flavescens*, smelt *Osmerus mordax*, burbot *Lota lota*, and northern pike *Esox lucius*. The acceptance of burbot or ling as a palatable fish appears to be on the rise, but many fishermen consider it an undesireable fish.

8.2.2 Winter Creel Census

Winter fishing supplies a major portion of the recreational fishing demand on Lake Simcoe. To better assess and manage the resource, the Fisheries Assessment Unit have conducted an extensive creel census each winter in which anglers are interviewed and catches examined. The lake is divided into twelve census areas (Figure 8.7). Records kept on tagged whitefish and marked lake trout provide essential data for population studies.

8.2.3 Winter Harvest Estimates

To compare harvest estimates from year to year, the winter creel results from 1965 to 1974 have been summarized to include a common seventy-five day base period from January 15th to March 31st. (Table 8.4). From 1965 to 1974, the estimated total number of angler hours has ranged from 402,000 in 1965 to a peak of 522,600 in 1970. The estimated total catch for all species has increased from 261,000 in 1964 to 560,200 in 1973 with a decline to 314,468 in 1974. In each successive year, beginning in 1965, yellow perch and smelt have comprised a higher portion of the angler harvest. The C.U.E. for all species has fluctuated between 0.47 (2.2 man hours/fish) and 1.19 (0.8 man hours/fish) in the period 1965 to 1974 (Table 8.5). The poorest C.U.E. of 0.47 occurred in 1970 while the best of 1.24 occurred in 1973.

Angler success for lake trout has fluctuated moderately from 1965 to 1974. An average of 1,400 trout were harvested each winter. Herring catches have undergone substantial fluctuations from year to year. Angler success for herring has ranged from a high of 0.25 (4.0 man hours/fish) in 1971 to a low of 0.11 (9.9 man hours/fish) in 1974.

Estimated harvests of whitefish have decreased from 153,300 fish in 1965 (2.6 man hours/fish, C.U.E. 0.38) to 21,500 (21.5 man hours/fish, C.U.E. 0.05) in 1974. Over the period 1965 to 1973, almost 1,000 times more smelt have been caught, from an estimated 250 in 1965 to 235,000 in 1973. A sharp, unexplained 61 per cent decrease in smelt harvest occurred during the winter of 1974.

An increase in yellow perch during the period 1965 to 1974, was also notable. In 1974, an estimated 177,500 yellow perch were harvested in contrast to 14,200 fish nine years ago. Catch levels for whitefish, yellow perch and smelt are graphically represented in Figure 8.8. Although perch are less popular than lake trout, whitefish or herring, creel census data indicate that more fishermen now actively fish for yellow perch compared to a few years ago.

8.2.4 Whitefish Population Studies

Population studies of Lake Simcoe whitefish conducted in 1972-1973 and 1973-1974, using a Peterson mark-recapture experiment, indicate that the number of spawning whitefish was in excess of one million fish. The winter harvest of

TABLE 8.4

SEASONAL ESTIMATES OF NUMBERS OF FISH CAPTURED BY ANGLERS DURING A 75 DAY ICE FISHING PERIOD 1965 - 1974

Year	1965	1966	1968	1970	1971	1972	1973	1974
No. of Angler Hrs.	401,981	390,208	499,360	522,624	397,326	466,719	438,645	440,187
No. of Whitefish	153,338	159,425	169,376	71,074	43,209	72,268	43,400	20,481
No. of Lake Trout	1,123	1,930	2,245	2,141	945	1,175	745	1,119
No. of Cisco	92,602	47,872	83,504	64,934	99,039	61,045	65,908	44,584
No. of Y. Perch	14,227	16,384	36,576	54,390	167,274	171,469	215,315	175,907
No.of Smelt	250	1,088	6,677	54,829	161,330	135,018	234,865	72,377
Total No. of Fish	261,540	226,689	298,378	240,828	471,797	441,575	560,253	314,468

TABLE 8.5 ANGLER C.U.E. AND MAN HOURS/FISH CAUGHT FOR WHITEFISH, LAKE TROUT, CISCO, YELLOW PERCH, SMELT AND ALL SPECIES COMBINED, (WINTER CENSUS DATA, 1965 - 1974)

	1965		1966		1968		1970		1971		1972		1973		1974	
Species	CUE	Hr/Fish	CUE	Hr/Fish	CUE	Hr/Fish	CUE	Hr/Fish	CUE	Hr/Fish	CUE	Hr/Fish	CUE	Hr/Fish	CUE	Hr/Fish
Lake Whitefish	0.381	2.6	0.408	2.4	0.338	2.9	0.135	7.4	0.108	9.2	0.155	6.5	0.102	10.1	0.051	2.15
Lake Trout	0.003	358.0	0.005	203.2	0.004	222.4	0.002	244.1	0.002	420.5	0.004	397.2	0.002	588.8	0.003	393.4
Shallowater Cisco	0.230	4.3	0.123	8.2	0.167	6.0	0.124	8.0	0.249	4.0	0.131	7.6	0.158	6.7	0.105	9.9
Yellow Perch	0.035	28.3	0.042	23.8	0.073	13.7	0.104	9.6	0.421	2.4	0.389	2.7	0.485	2.0	0.424	2.5
Rainbow Smelt	0.001	1607.9	0.003	358.6	0.013	74.8	0.105	9.5	0.406	2.5	0.367	3.5	0.496	1.9	0.166	6.1
All species	0.650	1.5	0.581	1.7	0.595	1.7	0.472	2.2	1.186	0.8	0.946	1.1	1.243	0.8	0.751	1.4

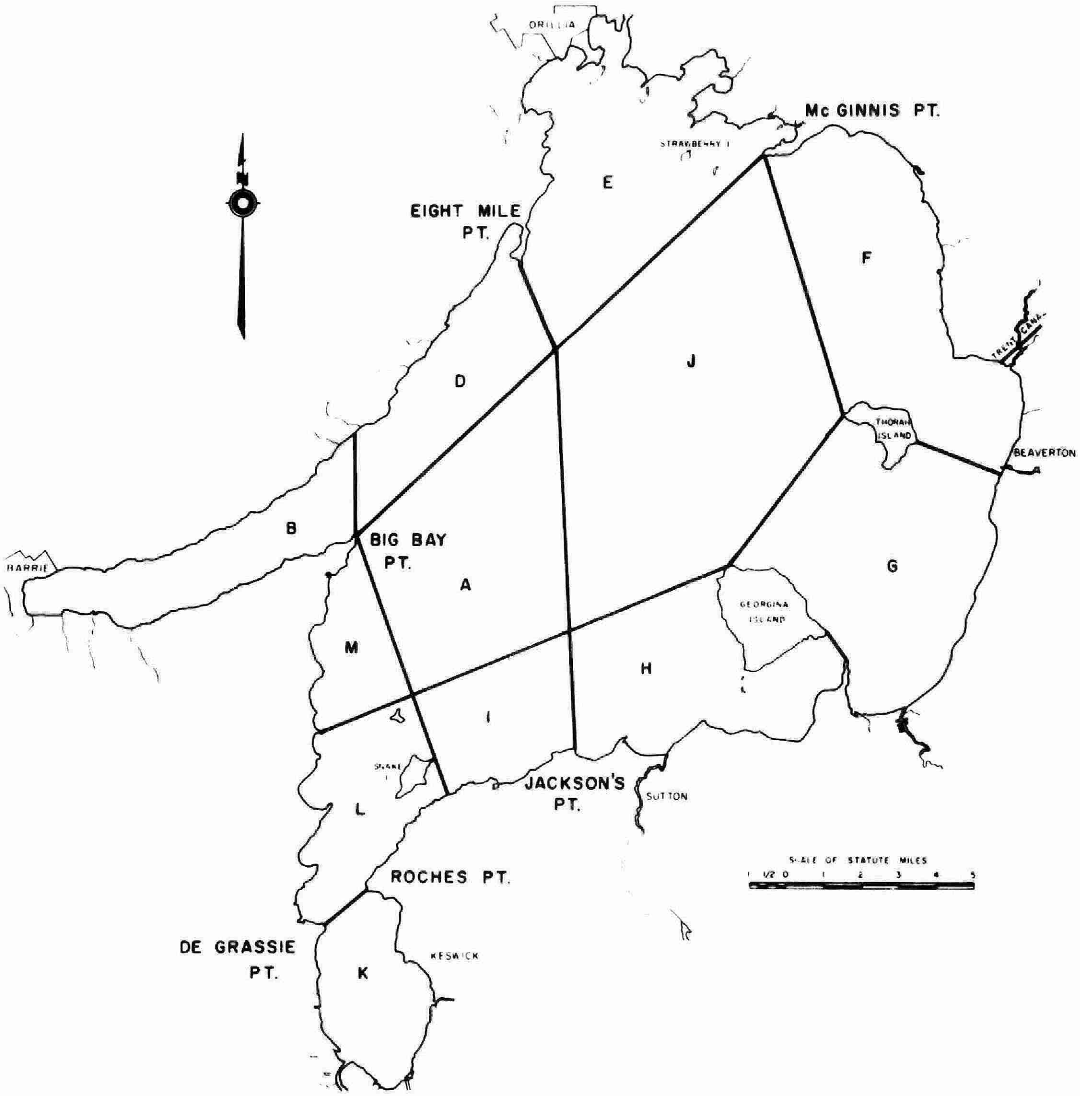


FIG. 8.7 LAKE SIMCOE WINTER CREEL CENSUS AREAS

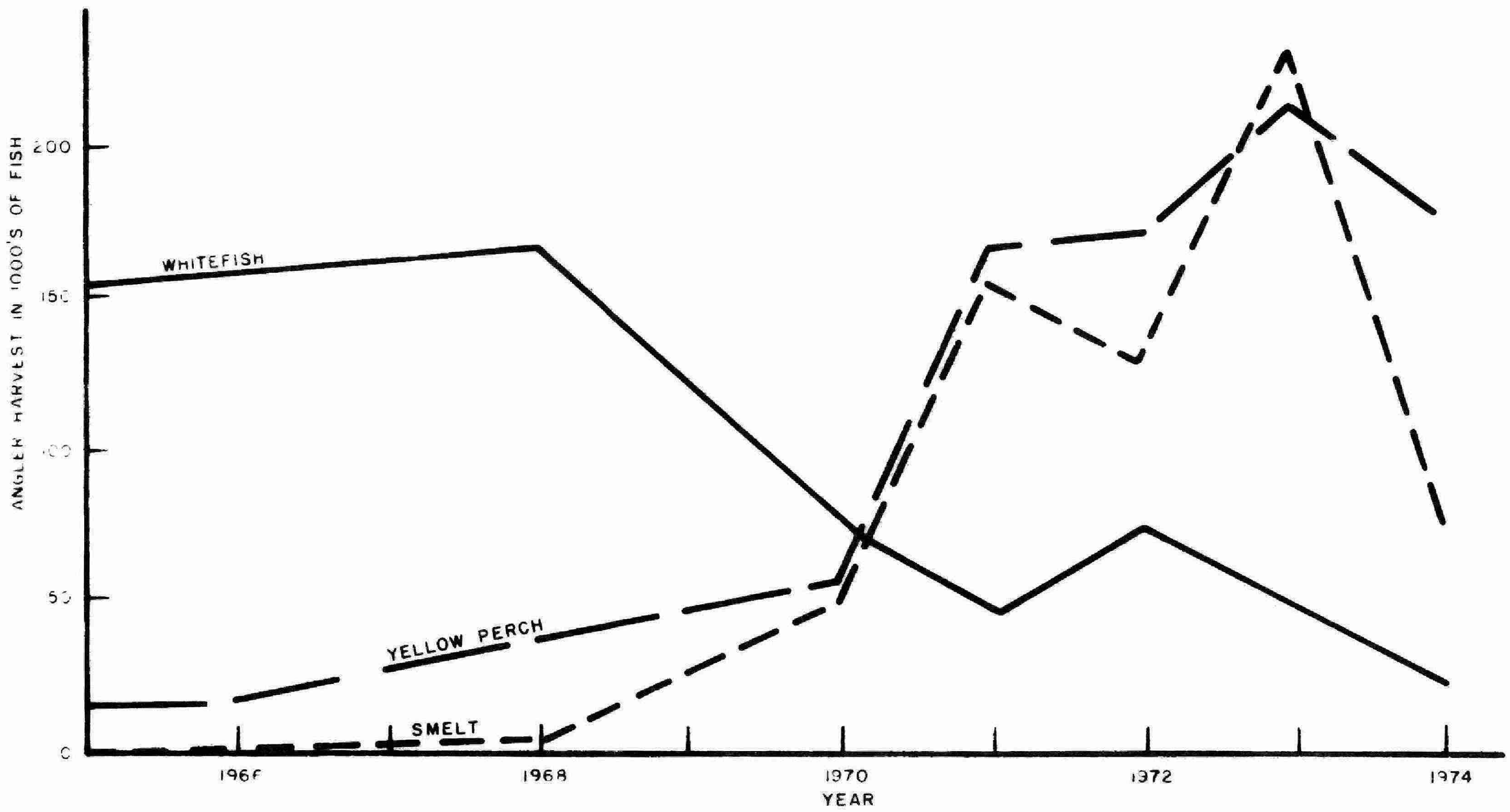


FIG. 8.8 WINTER ANGLER CATCHES OF WHITEFISH, YELLOW PERCH AND SMELT 1965 - 1974

whitefish, particularly in 1973 and 1974 (43,400 and 20,500 fish respectively) represented only a slight exploitation of spawning population of this size. Commercial exploitation of this species in other waters exceeds this rate by many times in self-sustaining populations (Cucin and Regier 1965). In spite of this the angler C.U.E. for whitefish has declined gradually but consistently over the last decade.

A greater number of large whitefish are now evident in the fishery. Today whitefish of 2 to 2½ pounds are common and the occasional fish of 4 pounds or more is taken. In contrast, Rawson in 1930 wrote, "The common whitefish of Lake Simcoe is abundant but of small size. The average weight of several thousand taken in 1928 was 1 lb. 2 oz., while a fish of 2½ pounds weight was quite unusual". Rawson suggested that the absence of the amphipod, Pontoporeia for food may limit the size of the whitefish in Lake Simcoe. Pontoporeia has been found to be a main food item of whitefish (Hart 1931, Reckahn-personal communication). Rawson thought that it was more probable that the small size was due to an overcrowding and a resultant competition for food.

MacCrimmon and Skobe (1970) suggested that the common Lake Simcoe whitefish is a slow-growing fish which remains relatively small through life, and that a separate relatively small population of whitefish which grows more quickly and attains a greater size was present. Semple (1968) found no apparent taxonomic difference among the whitefish of the lake, nor any appreciable differences in meristic features from those of the Great Lakes. Holder (1964) was unable to distinguish two races of whitefish.

Whitefish growth patterns have changed in the past few years. A nine-year-old whitefish in 1973 averaged 18.9 inches in total length compared to 16.1 inches for a nine year old in 1964 (Figure 8.9). A great many workers have observed reductions in population density and measured the resultant increase in growth rate. (Backiel and LeCren 1967). The change in growth rate is explained on the basis that growth depends on the food supply which in turn is dependent on the population density. The number of larger whitefish evident in the fishery is partially attributable to a predominance of older fish (eight, nine and ten year olds) making up 62 percent of the adult population (Figure 8.10). In contrast, 1964 age composition data of whitefish shows a predominance of younger age groups (Figure 8.11). In 1964, eight, nine and ten year old fish made up only 23 percent of the adult population while five and six year old fish comprised 55 percent. Reduced intraspecific competition due to limited recruitment of whitefish may explain the change in growth. However, relationships between food density and temperature effects on growth are other considerations.

8.2.5 Possible Effects of Smelt on Whitefish

Smelt could be a factor in the reduced recruitment of whitefish in Lake Simcoe; they have been cited as the

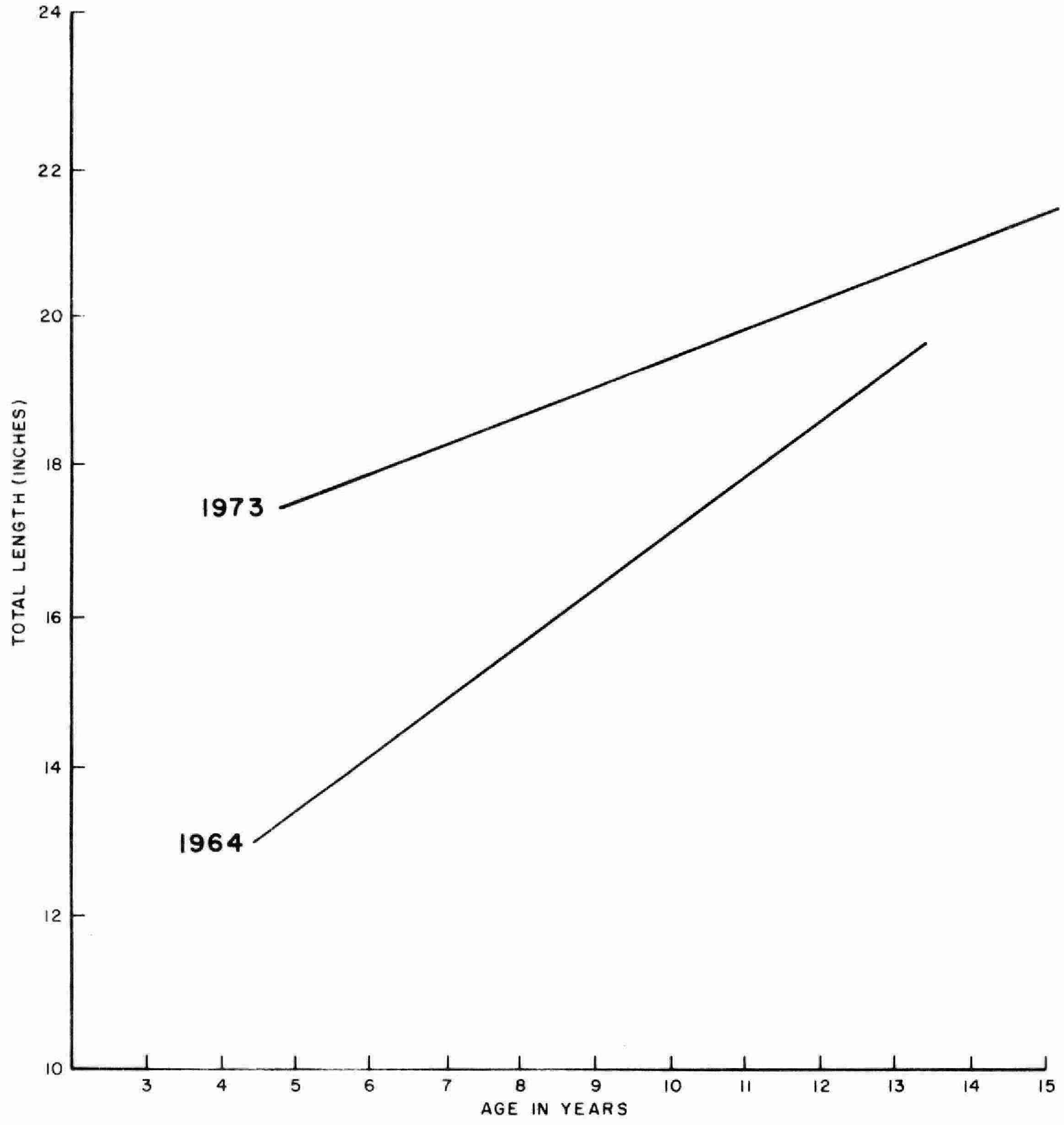


FIG. 8.9 COMPARISION OF 1964 AND 1973 GROWTH DATA OF LAKE SIMCOE WHITEFISH

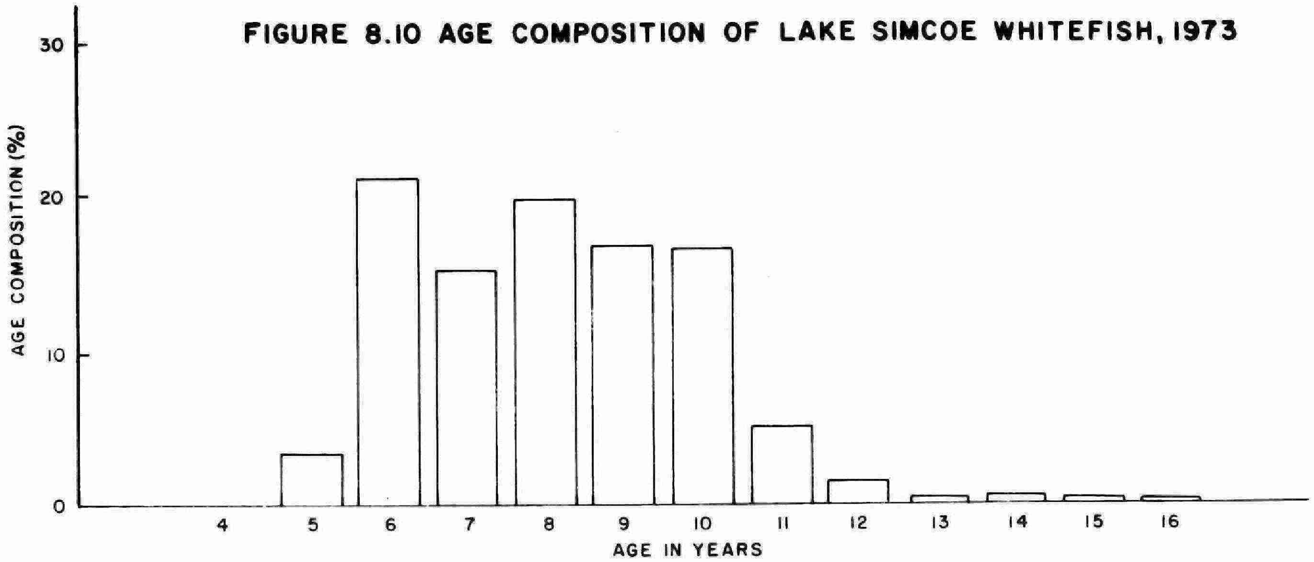


FIGURE 8.10 AGE COMPOSITION OF LAKE SIMCOE WHITEFISH, 1973

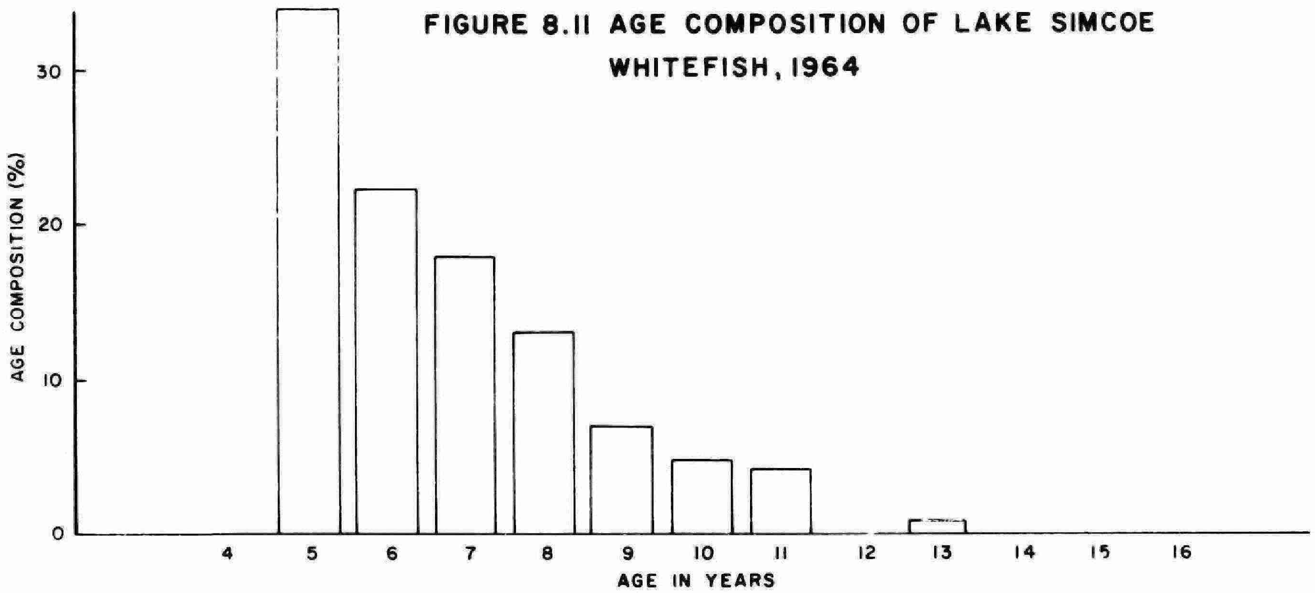


FIGURE 8.11 AGE COMPOSITION OF LAKE SIMCOE WHITEFISH, 1964

probable cause of whitefish declines in other waters (Cucin and Regier, 1965).

The feeding habits of smelt and whitefish are similar during various periods of their development and this could result in competition between the two species for available food resources. Smelt have been found feeding on young fishes and copepods in Mountain Lake, Michigan (Creaser, 1928) and zooplankton, benthic invertebrates and crustaceans were found in their stomachs in South Bay, Lake Huron (Baldwin 1950). Lake Michigan adult smelt were found to feed on shiners and young smelt in addition to zooplankton and benthic fauna (Gordon 1961). Lake Simcoe smelt have been found to feed on benthic invertebrates, zooplankton, shiners, young smelt, and what appeared to be sucker eggs. (Pugsley, personal communication).

The most common food items of adult Lake Simcoe whitefish are molluscs and aquatic insects, particularly nymphs and larvae of mayflies, chironomids and caddisflies (Rawson, 1930, MacCrimmon and Skobe, 1970). Hart (1931) found whitefish in Shakespeare Island Lake, Ontario feeding substantially on plankton in the first five years of life and Reckohn (1970) found the food habits of young whitefish to change from primarily plankton to principally benthic organisms during their fish year.

The similarity in feeding habits of smelt and whitefish could be particularly crucial when larval whitefish and smelt co-inhabit the mid-depths during midsummer.

Although smelt are recognized as effective predators of the young of various species, larval whitefish have not been found in the stomach of Lake Simcoe smelt and there is no evidence that smelt feed on whitefish eggs.

8.2.6 Possible effects of Yellow Perch on Whitefish

Rapidly increasing perch numbers in Lake Simcoe over the past 5 to 6 years may have influenced the recruitment of whitefish. Increases in perch may be partially attributed to the increasing abundance of rooted aquatic plants; weed areas provide safe breeding and nursery areas particularly favourable to the species. Preliminary information indicates slow yellow perch growth (Table 8.6) possibly due to increased intraspecific competition for food .

Immediately after hatching in the early spring, larval whitefish concentrate in shallow water inshore areas for approximately six weeks before they move into deeper water. Yellow perch also frequent these areas in the spring. Predation by perch on larval whitefish may have had an appreciable influence on whitefish recruitment.

Hart (1930) found heavy predation of whitefish eggs by yellow perch in Lake Ontario. (Twenty-one specimens ranging in length from 18 to 25 cm. (7 to 10 inches) examined November

TABLE 8.6

COMPARATIVE GROWTH DATA FOR
YELLOW PERCH

		AGE GROUP										
		0	I	II	III	IV	V	VI	VII	VIII	IX	X
Bay of Quinte, Lake Ontario, (Sheri & Power, 1969)	F.L. (in.)			6.2	6.8	7.2	8.0	8.5	8.2	10.1		
Lake Erie Ontario (S. Nepszy personal communication)	T.L (in.)	4.1	6.3	8.1	8.5	8.9	9.3					
Lake Simcoe	T.L. (in.)	2.6	4.4	-	-	-	7.3	8.3	8.5	9.3	9.4	10.5

2-7, 1926, all contained whitefish eggs, averaging over 200 eggs per fish).

Comprehensive studies on yellow perch feeding patterns would be required to determine the full impact of this species on Lake Simcoe's whitefish.

8.2.7 Other Factors Possibly Influencing Whitefish

The decline in whitefish may have been accelerated by changes in spawning and nursery habitat. Some siltation and encrustation is evident on spawning shoals but the exact effect, if any, on reduced egg hatching success is unknown. With periodic algal scums occurring, mats of algae may drift onto the spawning shoals where decomposition of organic material may deplete the oxygen supply and prevent successful hatching of eggs. This has also been suggested by Christie (1972). How significant an impediment this might be to egg survival is unknown and, as stated earlier, dissolved oxygen testing within the spawning shoals by OME has shown satisfactory conditions.

Hart (1930) stated that food availability upon absorption of the yolk sac is critical to young whitefish. If food is lacking at this period mortality will be high. Van Oosten and Hile (1947) found that the maximum growth in length of whitefish occurred in the first year of life. This period is critical and additional pressures from smelt and yellow perch may account for poor survival or young whitefish.

As pointed out in Section 5.1.4 dissolved oxygen levels in the hyploimnetic waters were drastically reduced by late summer and early fall. The possibility exists that lake trout and whitefish undergo stress in trying to avoid low oxygen areas in the bottom waters and high temperature areas above the thermocline. Whether or not this stress is of sufficient magnitude or length to have a pronounced effect on the salmonine-coregonine complex is not known.

8.2.8 Summary

Whitefish catch levels have declined substantially while catches of yellow perch and smelt have increased rapidly. Lake trout numbers had declined by the mid 1960's but the species still sustains an important fishery. Natural lake trout stocks are supplemented by plantings of yearling and two year old fish.

The exact reasons for the whitefish decline are unknown. Present data indicates low adult mortality and growth is high. This situation may result from high egg and larval mortality. Increased interspecific competition may be a factor in reducing the survival of young whitefish. It appears that whitefish recruitment is limited by some factor other than fishing mortality. Habitat deterioration may be instrumental in reducing the quality of the spawning shoals and may be placing additional environmental stresses on coldwater species. Given the present instability of the whitefish

population care should be taken to maintain an adequate brood stock.

8.3 DISCUSSION

A stressed aquatic community exhibits definite characteristics, one being a decline in coldwater fish stocks. The salmonids and coregonids are recognized as ecoligically sensitive fish taxa. Catches of whitefish and lake trout have declined while numbers of yellow perch and smelt have dramatically risen. The large population increases in yellow perch and smelt may have disrupted the lake's ecological balance.

The stabilization of the lake's fish populations is the prime goal of fishery managers. A major management strategy is the maintenance of a climax predator such as lake trout. Stocking lake trout supplements natural stocks and provides increased angling opportunities. Lake trout are also recognized predators of smelt (Christie, 1972).

The possibility of congrolling excess fish population through the introduction of an exotic piscivore such as coho or chinook salmon is possible, although exotic species often interact inexpectedly with existing fish populations causing altogether undesirable results. The stocking of an indigenous species such as lake trout is preferred.

If the whitefish is to continue as a major angling species, recruitment levels must be restored. Studies have been initiated to monitor whitefish egg development. A larval sampling program designed to locate whitefish hatching and nursery areas and monitor the first few weeks of life has been incorporated into the whitefish study. One of the methods of maintaining a species is through stocking. However, studies have shown that fry or egg stocking in lakes with established populations has no detectable effect on the abundance of whitefish (Van Oosten 1942, Miller 1952, Lapworth 1956, Christie 1963, Cucin & Regier, 1965).

Related studies on smelt and yellow perch feeding patterns are in progress to better evaluate species interrelationships.

Smelt and yellow perch are likely to continue doing well in Lake Simcoe. The smelt problem could be alleviated by reducing their numbers although complete eradication of the species would seem unlikely. The intensive removal of smelt by fishermen is encouraged during the spring spawning run when smelt are particularly susceptible to capture. An accelerated lake trout planting program would help curb smelt numbers.

The overabundance of yellow perch may be reduced through intensive perch trapping. Perch levels may be also curtailed by reducing aquatic weed growths. Weed areas provide safe breeding and nursery areas particularly favourable to the species.

Shallow water fish habitat must be protected; nearly all species of fish in the lake are found in shallow water at some season or period of their life history. This crucial area must be protected from ill-planned development projects which may irreparably influence and disrupt these areas and the fish species they contain.

The general public must become informed about the exhaustibility of natural resources and therefore the need to conserve them.

CHAPTER 9 - WATER QUALITY MANAGEMENT

As outlined in the preceeding chapters, findings of the Lake Simcoe Study indicate clearly that, while conditions are generally quite satisfactory for all normal water uses, the water quality of the lake is changing. To review briefly, the indications of change include:

(i) Algal scums first documented in the autumn of 1971 and noted every year thereafter.

(ii) Growth, over the past few years, of attached algae along previously clean shorelines,

(iii) Low dissolved oxygen in the hypolimnetic waters (2-3 mg/l) during the few weeks prior to autumn turnover (historical records are not available to determine if this is a long-term change or a recent occurrence),

(iv) Changes in the bottom fauna in the deep areas of the lake. (In the 1930's some species indicative of oligotrophic conditions were found. In the 1970's the hypolimnetic benthic community was typical of eutrophic conditions.), and,

(v) A decline in angling success for whitefish.

The Lake Simcoe Basin has traditionally been a prime recreational area and has recently been so defined by CORTS (1973). At the same time it is being viewed as an area for substantial urban development. High quality water for recreational pursuits can be maintained only if inputs of organics, nutrients, solids, salts and bacterial contaminants are minimized. Urban development (i.e. municipal sewage, storm drainage, etc.) brings with it all of these polluting substances. In order to reconcile these apparently diametrically opposed uses and ensure against degrading water quality conditions in the basin, a water quality control plan for the tributary basins and Lake Simcoe has been developed and is presented in this chapter.

9.1 WATER QUALITY CONTROL - TRIBUTARY STREAMS

Three thousand one hundred and twenty-five square kilometers (1,200 square miles) of Central Ontario are drained by rivers and streams flowing to Lake Simcoe. In general water quality in these streams is satisfactory; however, degraded water quality conditions, as evidenced by low or widely fluctuating dissolved oxygen levels and excessive aquatic plant and algae growth, exist in several areas. Poor quality may occur naturally in swampy areas, generally south of the lake, but most problems result from oxygen demanding and nutrient materials discharged from municipal sewage treatment plants, uncontrolled urban and rural runoff and other diffuse sources.

The Ontario Ministry of the Environment has conducted detailed investigations and established organic waste loading

At the time of publication, these guidelines* were:

Town of Newmarket	- 45/kg/day (100 lb/day) BOD_5
Town of Aurora	- 136 kg/day (300 lb/day) BOD_5
Town of Uxbridge	- 27 kg/day (60 lb/day) BOD_5
Village of Cannington	- several alternatives for seasonal discharge lagoons or a 0.68 migd tertiary mechanical plant with an effluent quality of 8 mg/l BOD_5 and 4 mg/l dissolved oxygen
Town of Sutton	- maximum 8000 people
Township of East Gwillim-bury-Holland	- maximum 3000 people with seasonal discharge to Holland River

*Some of the above waste loading guidelines are currently under review and may be altered.

In 1974, the Ontario Ministry of the Environment required that all municipal sewage treatment plants in the Lake Simcoe Basin exceeding the capacity of one million gallons per day provide phosphorus removal to one mg/l in the final effluent.

Application of these guidelines will result in improved dissolved oxygen conditions in the streams and phosphorus control will reduce the total tributary phosphorus loading to Lake Simcoe by about 50 percent, and should reduce algal production downstream from municipalities. With the pressure for development in larger municipalities it is likely that, with the increased sewage flow, BOD_5 loading guidelines will be exceeded (as is already the case in Aurora and Newmarket), resulting in further degradation of water quality in the tributary streams. In addition, the increased sewage flow will result in greater phosphorus loadings which will ultimately reach Lake Simcoe.

With the construction of the York-Durham Provincial Sewage Works, municipal wastes from Aurora and Newmarket will be directed to this pipeline for ultimate treatment and discharge to Lake Ontario. The removal of these two major sources of waste material should result in significant water quality improvements in the Holland River System and will result in a reduction in the phosphorus loading to Lake Simcoe.

i.e.: Phosphorus loading to Lake Simcoe from the Holland River:

(i) Prior to phosphorus removal in 1974 - 37 metric tons/year

(ii) Following phosphorus removal in 1974- 28 metric tons/year

(iii) Aurora/Newmarket loadings removed - 22.5 metric tons/year

While this reduction (from 28 to 22.5 metric tons/yr) may appear small, it will result in less nutrient and organic material being available for aquatic plant growth between Aurora and Newmarket and especially downstream from Newmarket, in algae-choked Roger's Reservoir. With plant growth being reduced, severe fluctuations in dissolved oxygen (resulting from the photosynthesis and respiration of the plants) should be minimized. As well, oxygen-demanding organic inputs will be reduced to the river, further protecting the oxygen resources of the stream.

Further downstream, in the Holland Marsh nutrient-rich surface water runoff is being pumped from the South Marsh to the Holland River. While it is difficult to control surface runoff it is important that fertilizer applications be controlled to prevent excessive amounts being applied (which would eventually find their way to the drainage ditchs and hence to the West Holland River) while optimizing crop growths.

Smaller municipalities (Mount Albert, Sunderland) currently disposing of domestic wastes in private septic tank facilities are contemplating municipal sewage systems. Because these municipalities are located in headwater areas, alternatives to discharging to small streams will be required if satisfactory water quality conditions are to be maintained.

Further reductions in material inputs to the streams can be achieved by eliminating uncontrolled domestic wastewater discharges, treating storm drainage and minimizing inputs from land use activities, such as agriculture, by proper management techniques. Detailed recommendations for pollution control practices are presented in Section 9.3.

9.2 WATER QUALITY CONTROL - LAKE

As outlined in Chapter 6, directly-discharging municipal sewage treatment plants and tributary streams contribute substantial material loadings to Lake Simcoe. Intensive studies in the vicinity of these sources as discussed in Sections 5.2 and 5.3 show that the materials discharged may impair quality and, in a few cases, restrict uses directly adjacent to the source. However, the materials discharged are quickly disipated and do not appear to cause wide-spread or serious problems as indicated by water chemistry. In the long-run however, the cumulative effects of phosphorus and other deleterious substances do contribute to the lake-wide biological changes and other problems identified in Lake Simcoe. No sources of material inputs, therefore, can be ignored.

Discharges containing bacterial organisms, in general, do not result in wide-spread or long-term water quality impairment related to activities such as swimming. However, on occasions in the past, water use restrictions resulting from high bacteriological levels have been documented. Bacteriological impairment in these cases was likely the result of inadequate sewage disinfection or unauthorized discharges.

Shingle and Kempenfelt Bays, directly influenced by treated wastewater discharges from Orillia and Barrie, should show some reductions in algal growth in the future now that phosphorus removal facilities are in operation. Phosphorus removal at the Aurora and Newmarket sewage treatment plants and, in a few years, the elimination of these wastewater discharges from the Holland River system, should result in a substantial reduction of phosphorus in Cook Bay and ultimately the open water areas of Lake Simcoe.

Nutrient inputs are of major concern in the open waters of Lake Simcoe. Nitrogen and phosphorus from sewage treatment plant discharges, uncontrolled urban and agricultural land drainage, the atmosphere and possibly private septic tank systems are causing water quality problems in the form of algal scums and attached algal growth which detract from the aesthetic and recreational value of the lake and ultimately contribute to oxygen depletion in the hypolimnetic waters.

As discussed in Section 7.1.3, nitrogen is abundantly available in all material sources to the lake and can be extracted directly from the atmosphere by certain blue-green algae found in Lake Simcoe. The availability of nitrogen to the lake from the various sources is extremely difficult if not impossible to control. Removal at sewage treatment plants is not economically or practically feasible at this time. Thus, nitrogen control cannot realistically be considered as a practical means for limiting biological growth.

Phosphorus is also present in all discharges to the basin but is not available to algae directly from the atmosphere.

The largest sources of phosphorus to the Lake Simcoe Basin are the municipal sewage treatment plants. Prior to phosphorus removal in 1974, these sources accounted for 45 percent of the total phosphorus input to the lake. Phosphorus in municipal sewage is readily removable by chemical precipitation. In 1974, all the major municipal plants in the basin were required to reduce total phosphorus in the final effluent to no more than one mg/l. It is calculated that this improved treatment has resulted in a phosphorus loading reduction of about 38 metric tons (41 tons) per year or 30 percent of the total phosphorus input from all sources. The magnitude of these reduced municipal STP loadings in relation to other sources of phosphorus is presented in Figure 9.1. A graphic illustration of the effects of phosphorus removal can be seen by comparing Figure 9.1 to Figure 7.3.

In addition to improved treatment at municipal sewage works, material inputs, including phosphorus, can be reduced through urban storm drainage control, efficient land management, and other measures undertaken by lake residents as outlined in detail in Section 9.3 - The Water Quality Management Plan.

9.2.1 Control of Algal Growth

In the past few years, limnologists have developed modelling techniques which permit the prediction of the reaction of aquatic plant growth to phosphorus input.

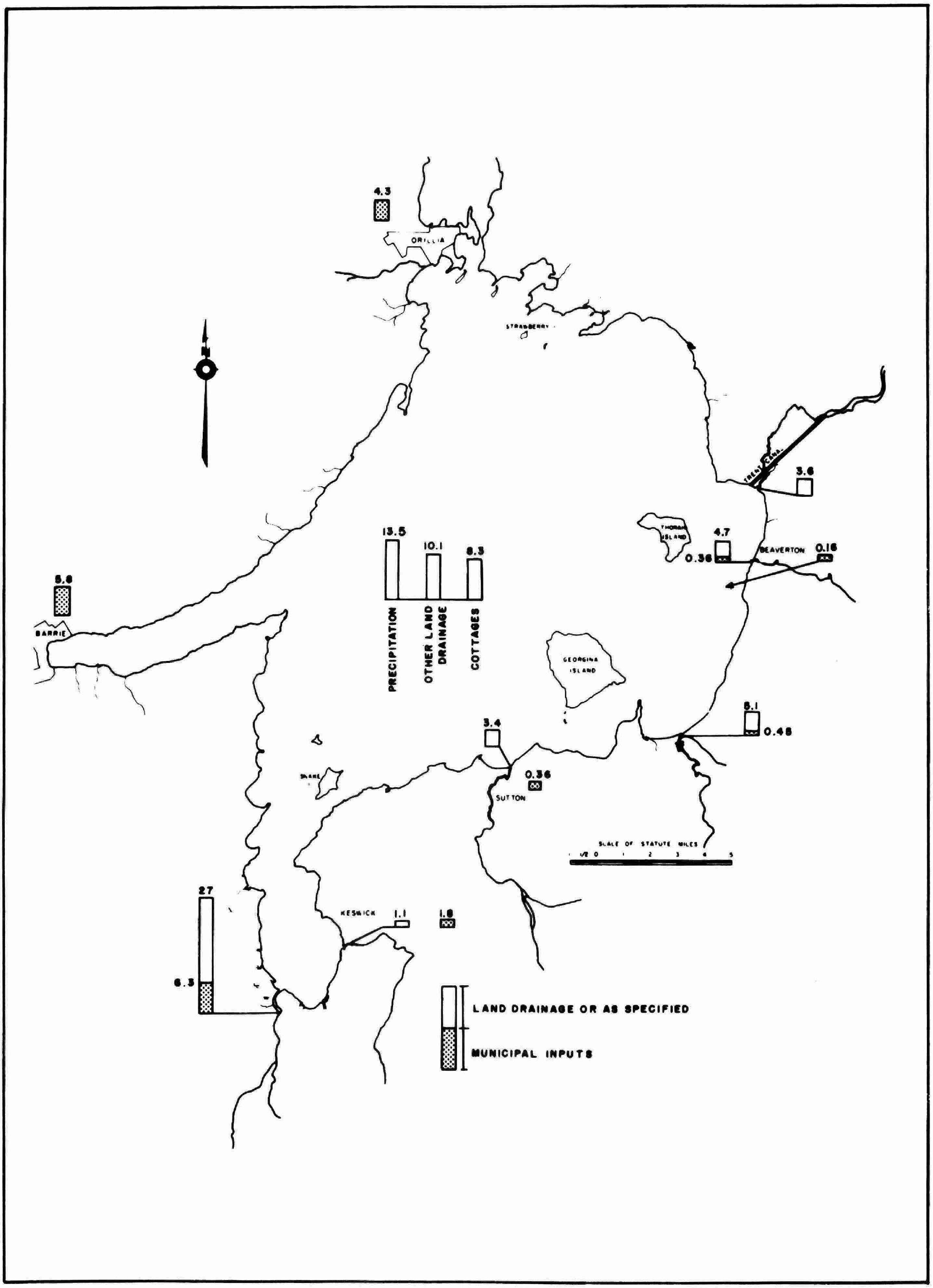
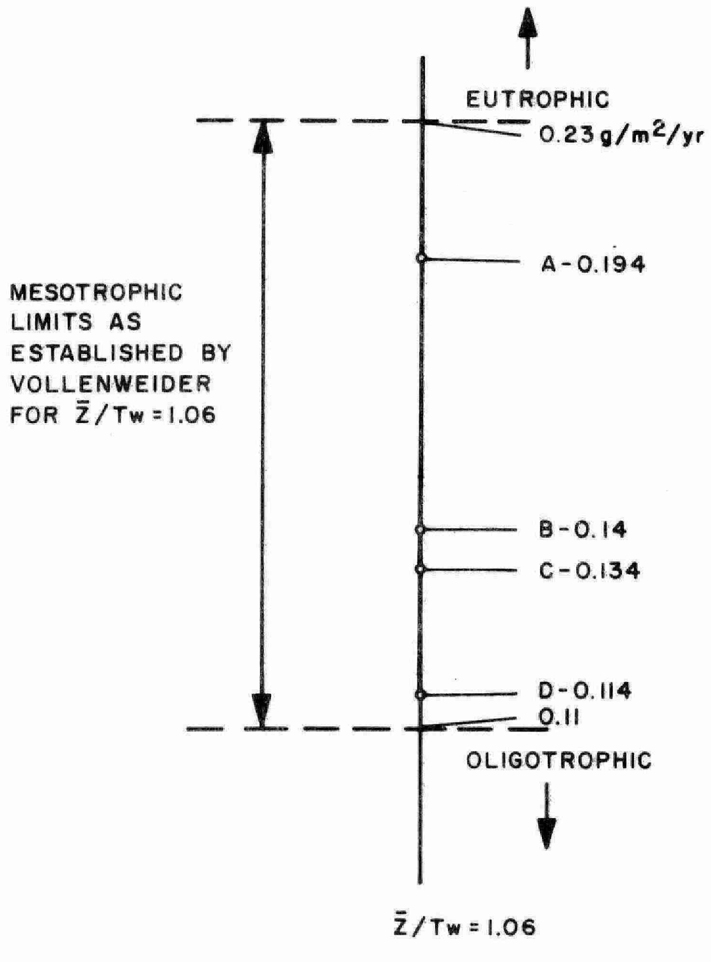


FIG. 9.1 NET TOTAL PHOSPHORUS INPUTS FOLLOWING PHOSPHORUS REMOVAL AT STPs (METRIC TONS/YR)

One such technique, developed by R. A. Vollenweider (in press), relates the degree of eutrophication (i.e. aquatic biomass production) to the gross annual loading of nutrient materials. For assessing possible changes in the trophic status of Lake Simcoe, the nutrient phosphorus, was reduced to a unit area-time loading (grams per square meter per year) and related to the mean lake depth divided by the total flushing time (i.e. the total time required to fill the lake basin at current net inflow rates). A detailed breakdown of the values used in this relationship for Lake Simcoe are given in Table 9.1.

In Figure 9.2 the unit area - phosphorus loadings in Lake Simcoe prior to, and following phosphorus removal at the STP's, are presented and related to the degree of eutrophy as defined by Vollenweider.



WHERE A - PRIOR TO PHOSPHORUS REMOVAL AT STPs } 13 mgd FROM STPs
B - FOLLOWING PHOSPHORUS REMOVAL AT STPs }
C - FOLLOWING PHOSPHORUS REMOVAL AND WITH AURORA & NEWMARKET WASTES DIVERTED TO YORK-DURHAM SCHEME
D - HYPOTHETICAL CASE - ALL PHOSPHORUS REMOVED FROM STP DISCHARGES

FIG. 9.2 CALCULATED TROPHIC STATUS OF LAKE SIMCOE UNDER VARIOUS PHOSPHORUS LOADING CONDITIONS

TABLE 9.1 CALCULATION OF UNIT AREA LOADING AND $\overline{Z}/Tw$

(i) Unit Area Loading

(a) Gross Phosphorus Loadings

Sources	Yearly Loading Metric Tonnes	Yearly Loading Imperial Tons
Municipal STP's (prior to P removal)	58	64
Tributary Basin Drainage	41	
Precipitation	21	23
Direct Land Drainage	13	14
Cottage Septic Tank etc.	8	9
	141	110

(b) Lake Surface Area - 725×10^6 m^2 (280 sq. mi.)

$$\text{Unit Area Loading} = \frac{141 \times 10^6 \text{ gms}}{725 \times 10^6 \text{ m}^2}$$

$$= 0.19 \text{ gm/m}^2\text{/yr}$$

(ii) Mean Depth/Flushing Time = $\overline{Z}/Tw$

(a) Mean Depth - 17 meters (56 ft)

(b) Total Volume of Lake Simcoe - $725 \times 10^6 \times 17 = 12.3 \times 10^9$ m^3

(c) Net Inflow (Total inflow less evaporation, loss to ground water etc., i.e. surface outflow)

$= 24.4$ m^3/sec (860 cfs avg. long term)

(d) Flushing Time $= \dfrac{12.3 \times 10^9}{24.4} = 0.504 \times 10^9$ sec = 16 years

$\overline{Z}/Tw = 17/16 = 1.06$

For the calculation of levels of eutrophy in Figure 9.2, it was assumed that the phosphorus loadings from all sources other than the STP's (i.e. land drainage, precipitation, etc.) were constant. It is interesting to note that in the hypothetical example of all phosphorus being removed from STP effluents, the trophic status of Lake Simcoe would be close to the upper limit of the oligotrophic zone.

With the appearance over the past few years of algal scums, attached algae growth and other indicators of a probable change in the trophic status of Lake Simcoe, it is obvious that the total phosphorus loading of 0.19 $gm/m^2/yr$, as calculated from information obtained during the study, is too high and must be reduced substantially if algal growth is to be checked.

With the recently implemented phosphorus removal program in the Lake Simcoe Basin, calculations indicate that the phosphorus loading has been lowered to 0.14 $gm/m^2/yr$. Although this decrease in loading has not yet been reflected in reduced phosphorus levels in the open lake waters, limited sampling showed a small reduction in chlorophyll a in the euphotic zone. This change, however, may well be the result of water temperatures, increased sunlight or other functions of plant growth. Samples collected over the next few years should reflect reduced phosphorus levels and algal growth as a result of the phosphorus removal program.

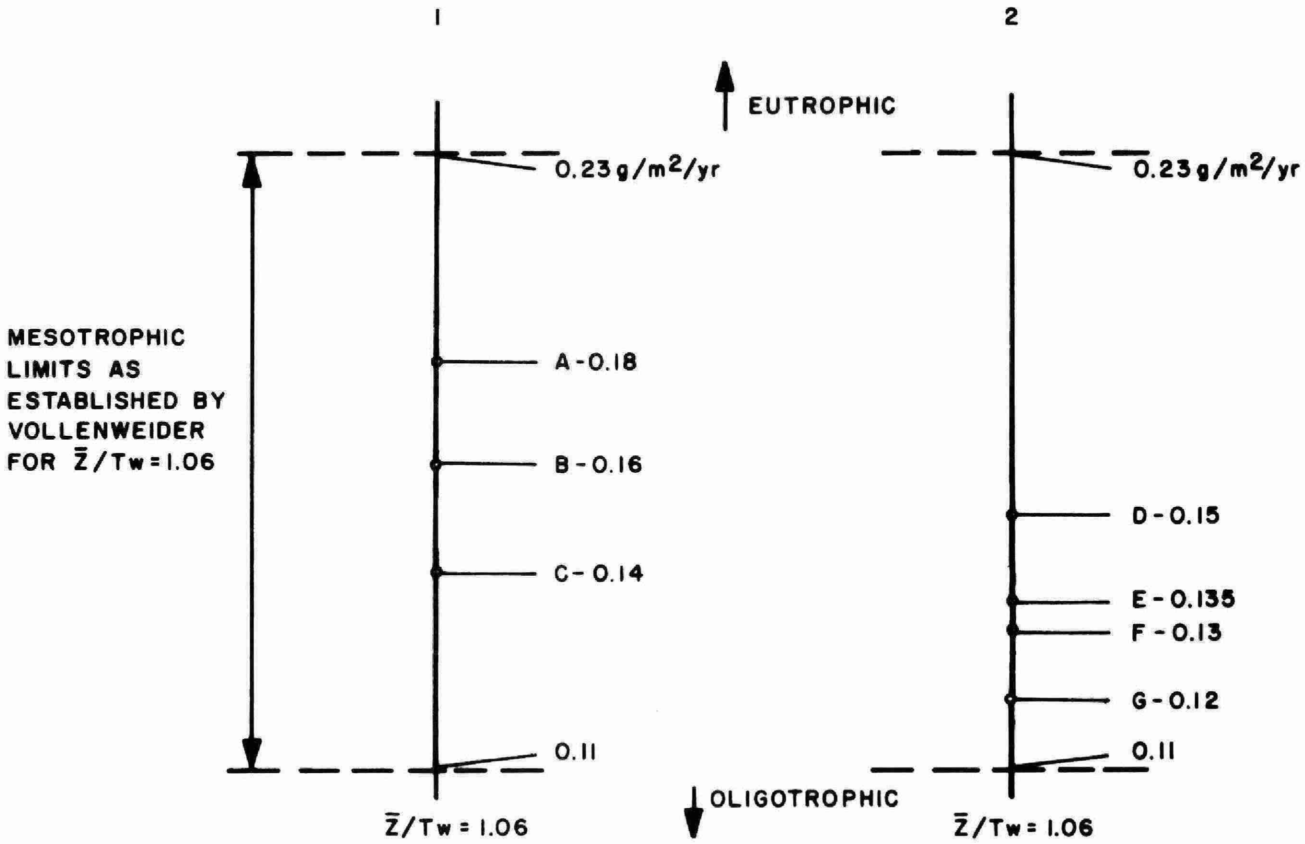
9.2.2 Phosphorus Loadings in the Future

As stated earlier in this report, the Lake Simcoe Basin is being seriously viewed as a potential area for major urban expansion. With urban development, wastewater discharges from sewage treatment plants and urban land runoff will increase and the present phosphorus loading of 0.14 $gm/m^2/yr$ will begin to rise. While it is not presently known what level of phosphorus loading is required to maintain a healthy balance between aquatic biomass production and water uses, every effort should be made to ensure that the lowest level of phosphorus be strived for in all wastewater discharges that can possibly be controlled.

Examples of unit area phosphorus loadings for sewage treatment plants with phosphorus removal to 1.0 mg/l and further reductions to 0.3 mg/l are presented in Figure 9.3. No attempt was made to account for further phosphorus reductions resulting from improved land use practices, upgrading septic tank facilities or other actions which would minimize material inputs from diffuse land use activities; conversely, additional phosphorus loadings were not included from land drainage associated with increased urban development within the basin.

With the control of phosphorus which will result in an accompanying decrease in algal production, the mass of dead algae cells now settling to the bottom of the lake underlying the hypolimnetic zone will be reduced. This reduction in the oxygen demanding decaying algae and further reductions in

organic particulate matter from STP discharges and land drainage may reduce oxygen depletion in the hypolimnetic zone during the period of thermal stratification, thus creating a more desirable habitat for the cold-water fishery.



WHERE	A	-	UNIT	AREA	LOADING	FOR	30 mgd	- 1 mg/l	IN	EFFLUENT
1	B	-	"	"	"	"	20 "	"	"	"
	C	-	"	"	"	"	10 "	"	"	"
	D	-	"	"	"	"	50 "	0.3mg/l	"	"
2	E	-	"	"	"	"	30 "	"	"	"
	F	-	"	"	"	"	20 "	"	"	"
	G	-	"	"	"	"	10 "	"	"	"

FIG. 9.3 UNIT AREA PHOSPHORUS LOADINGS UNDER VARYING STP FLOWS AND PHOSPHORUS CONCENTRATIONS IN FINAL EFFLUENTS

To this point, enhancement of the open-water areas of the lake has been stressed. Protection of water quality and use in the

bays and near-shore zones must also be considered in light of increasing urbanization, recreational development, etc. While the unit area loading concept which lumps together all sources, may suggest the loading limits for the protection of the open lake, individual sources of pollution may result in localized impairment. Wastewater discharges containing deoxygenating organic materials, nutrients, particulate matter, bacteria and other pollutants must be evaluated and managed for the protection of lake-wide and local water quality conditions.

9.3 WATER QUALITY MANAGEMENT PLAN

With the incorporation of phosphorus removal at major sewage treatment works in 1974, the total phosphorus loading has been reduced from 0.19 to about 0.14 $g/m^2/year$. This 25 per cent decrease in phosphorus loading should result in reduced biomass production over the next few year, thus upgrading the quality of Lake Simcoe waters.

Tributary basins draining to Lake Simcoe and some near-shore areas are, in some cases, degraded as evidenced by oxygen depletion or excessive aquatic plant and algae production. Improved sewage treatment and the minimization of wastewater inputs from other diffuse sources should result in upgraded water quality in these streams and bays and, ultimately, improvement in Lake Simcoe water quality.

With the plans for development currently being considered for the Lake Simcoe Basin, further wastewater discharges can be expected and material loadings such as organics and nutrients will increase. Unchecked, phosphorus loadings could again approach or exceed the 0.19 $g/m^2/year$ rate which has likely caused the water quality problems that have begun to appear over the past few years.

To restore and maintain a high level of water quality compatible with all water uses, the following waste treatment and pollution control guidlines should be implemented.

9.3.1 General Development Considerations

Land use development (residential and industrial expansion, cottage and campsite development, etc.) in the Lake Simcoe Basin should proceed in an orderly, well-planned manner. Matters concerning wastewater discharges to the lake or tributary streams should be reviewed to incorporate both the local and lake wide implications on water quality and use. Major development should be staged so that the impact of development on water quality can be assessed and future development managed in light of reserve capacities within the basin.

9.3.2 Specific Requirements

(a) Municipal Sewage Treatment Plants

All existing sewage treatment plants must be maintained at

their highest level of treatment efficiency. Where BOD_5 loading guidelines have been established, these levels must not be exceeded. All treatment plants with phosphorus removal facilities must ensure that total phosphorus in the final effluent is reduced to the lowest achievable level. New sewage treatment plants or extensions to existing plants should incorporate the most up-to-date equipment, procedures, etc. to ensure the highest level of treatment practicably possible. Particular attention should be given to eliminating organic solids and reducing total phosphorus inputs. It is suggested that all new plants or existing plant expansions with discharges to Lake Simcoe incorporate extended aeration and continuous sand filtration or other sophisticated treatment systems to guarantee consistent, good quality final effluents.

In the tributary streams draining to Lake Simcoe, plants that would discharge to headwater areas should be discouraged. Wastewater discharges from the Aurora and Newmarket sewage treatment plants should be directed as soon as possible to the York-Durham Provincial Sewage Works System.

Municipal sewage lagoons with seasonal discharge should be discharged in the late fall and, if necessary, during the early spring prior to the aquatic plant growing season. All lagoons should be treated for phosphorus removal prior to discharge.

Wastewater discharges containing bacterial contaminants which could potentially affect the quality of Lake Simcoe must receive adequate disinfection.

(b) Uncontrolled Urban Drainage

Municipal or industrial sewage gaining direct access to the lake or tributary streams should be intercepted and directed to the municipal sewage treatment facility.

In all new urban developments, consideration should be given to providing storm water treatment prior to discharge to the lake.

In existing municipalities where storm water treatment is not practicably possible, good houskeeping practices should be employed to minimize the impact of storm water drainage (i.e. routine programs of street sweeping, cleaning of catchment supms, conservative use of deicing salts, etc.).

(c) Agricultural Drainage

Farmers can ensure that runoff from barnyards, manure piles, silos, etc. does not gain access to the rivers or lake. Soil and fertilizer losses should be minimized through proper land management techniques.

(d) Other Sources

Individuals can contribute to maintaining a high level of water quality in Lake Simcoe in several ways:

- cottagers can ensure that their sanitary and lavatory wastewater discharges are disposed of in properly installed and maintained facilities. Lawn and garden fertilizers should be used conservatively. Soap may be used instead of detergents to minimize phosphorus discharges.

- boaters should ensure that their motors are operating efficiently. Proper use should be made of holding tank pumpout facilities. Litter should be retained and disposed of ashore.

To conclude, the responsibility for the preservation of water quality conditions compatible with all desired water uses rests with the province, the municipalities and the individual. Phophorus reduction at the major sewage treatment plants is an important first step, but activities ranging from responsible planning and development of new communities to the upgrading of private waste treatment facilities are all essential if Lake Simcoe is to maintain its traditional reputation as a prime recreational area.

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